ILLUMINATING ENGINEER

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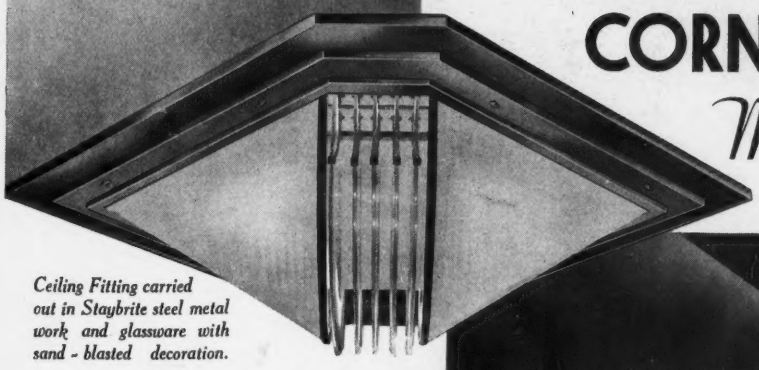

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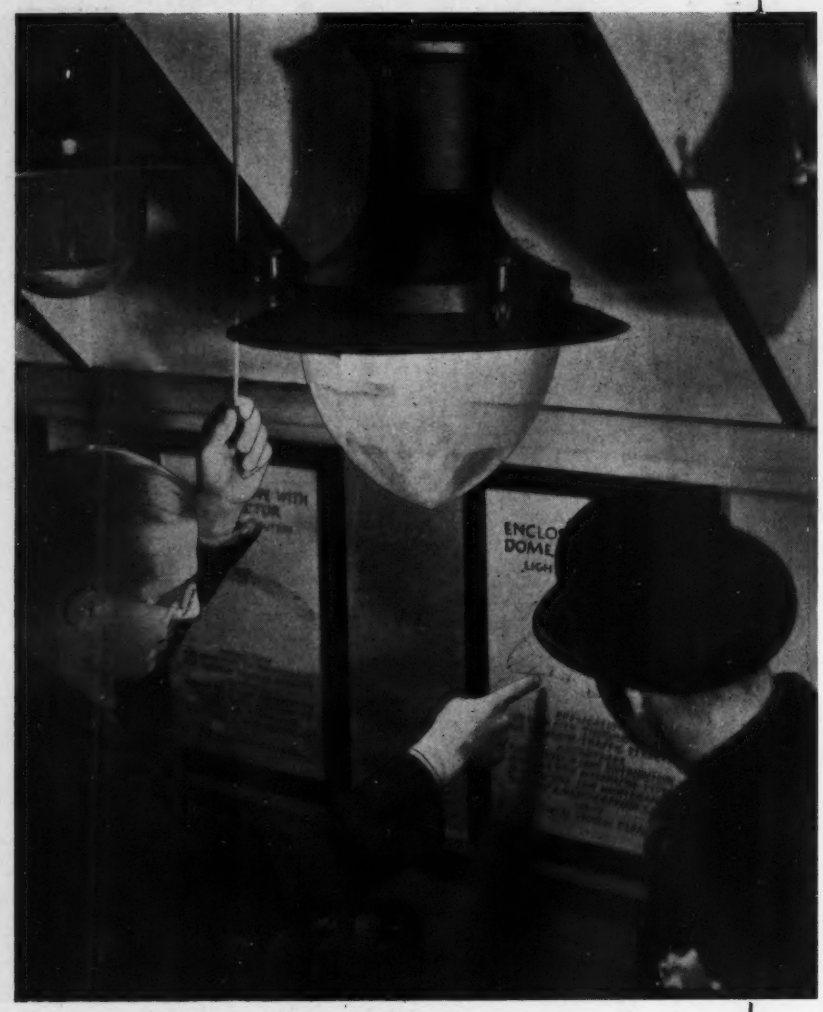

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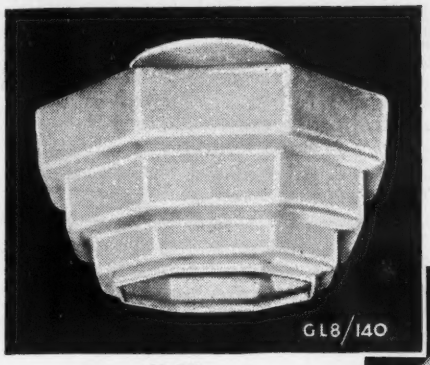

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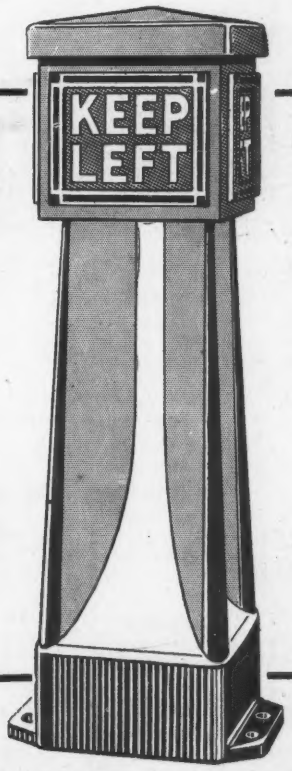

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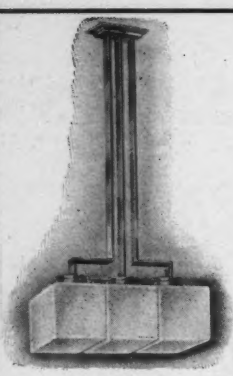

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As King Richard lay pining in gaol,
He said "Warder, I grow thin and pale!
Bring me lamps of great size,
To gladden my eyes."

. . . . . .

Hailware'd have brought joy, without fail.

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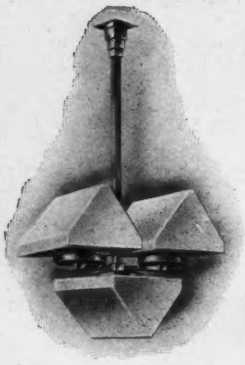

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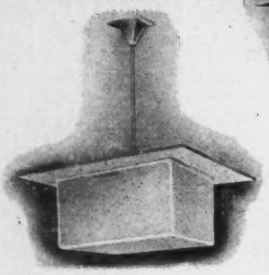

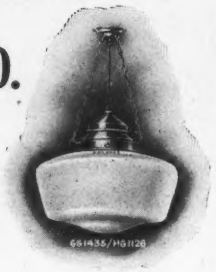

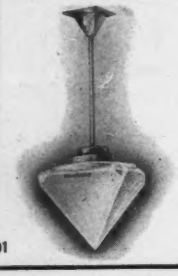

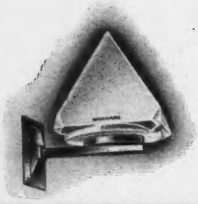

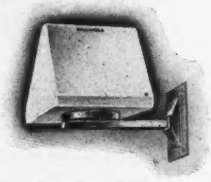

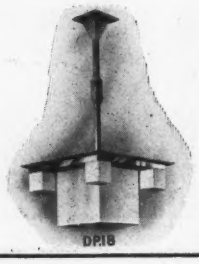

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Official Journal of THE ILLUMINATING ENGINEERING SOCIETY
FOUNDED IN LONDON 1909
INCORPORATED 1930

The ILLUMINATING ENGINEER

THE JOURNAL OF GOOD LIGHTING

Edited by

J. STEWART DOW

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How Much Light Do We Need?

HOW much light do we need?

It is strange that, notwithstanding all the efforts of the Illuminating Engineering Society for the past twenty-five years, we cannot—even to-day—answer this question quite satisfactorily.

The intensity of illumination by night is almost invariably far less than that available in the daytime. Considerations of economy alone prevent our reproducing the intensity of daylight. Our ideas as to what is necessary are in the main founded on " current practice " (as represented in familiar tables of illumination-values)—on what *is* rather than on what ought to be. There have been few efforts as yet to grapple with the problem on fundamental principles, to ascertain by scientific tests exactly how much light we do need for various purposes.

Two alternative lines of research suggest themselves. One might try to show that when the illumination falls below a certain value eyestrain or injury to health results. We are all aware that continuous work by inadequate light must have prejudicial effects on health. Experiments of this kind, however, present evident difficulties and it would need a very long and continued research to establish, in specific cases, that defects in lighting have caused actual physical injury.

Another and a more fruitful plan is to trace the results of better lighting in the form of improved output and greater accuracy of work. This has in fact been done most successfully in certain cases—for example, in the famous study by H. C. Weston and A. K. Taylor of the effect of illumination on the efficiency of fine work (type-setting by hand).* But these tests, too, occupy much time and require great care, and obviously can only be applied to certain processes.

A third method, and a promising one, is that outlined in Mr. Beuttell's recent paper before the Illuminating Engineering Society, which is based on an analysis of the visual task. Such factors as size of object illuminated, contrast, moving vision and emphasis—all of which play a part in deciding the requisite illumination, are in turn assessed. Due weight is given to each by applying appropriate multiplying factors to a certain basic illumination. Naturally the determination of these multiplying factors is a crucial point; for the time being this may have to be settled on an empirical basis, though ultimately it should rest on scientific basis. But even so the method seems useful and presents the signal advantage of enabling each lighting problem to be studied on its merits. We advise all readers to study this paper (see pp. 5-11), which may well prove a landmark in the history of Illuminating Engineering.

An Analytical Basis for a Lighting Code
(See page 5)

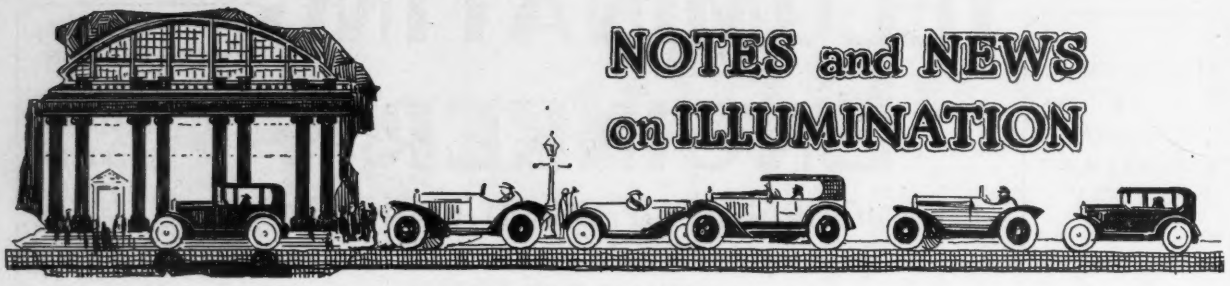
★

The New Battersea Power Station
(See page 19)

★

A New Form of Show-Window
(See page 24)

* Joint Report of the Industrial Fatigue Research Board and the Illumination Research Committee; H.M. Stationery Office, 1926.



Seeing is Believing

" Seeing is believing " applies with special force to measurements of illumination. People are at once impressed if one can show, by the reading of a photometric instrument, that their illumination is up to standard. It is in this way that the new direct reading illumination photometers, based on the use of photo-electric cells, prove so useful. Any drawbacks as regards accuracy are compensated by the great advantage that the observer has only to watch the movement of a pointer, which can be seen by several people at the same time. This was illustrated in a recent court case in which compensation was claimed on the ground that an accident was caused by insufficient light. The defendants demonstrated that the illumination, as registered by a direct-reading photometer, was at least considerably greater than that prevailing in the court!

" Plastic " Illuminating Material

The making of organic plastic materials has already developed into a new industry—as was evident at the Exhibition held in London last March. A recent paper, discussing their value in connection with lighting, read before the American Illuminating Engineering Society by A. Paulus and C. S. Woodside, is, therefore, timely. As reflecting surfaces the utility value of such materials seems established, although improvement in transmission factors is needed. Apparently little discolouration need be feared in white (cloudy) material under normal operating conditions, and coloured plastics are reasonably resistant to fading. The toughness and light weight of such materials should render them specially useful for large pendant indirect lighting units and for the lighting of ships and aircraft.

Winter Bowls

It was recently stated in the " News Chronicle " that bowls, played on a special carpet during the winter time, may soon become familiar to London. The preparation of greens for outdoor play and carpet-surfaces in covered buildings is contemplated at the proposed new headquarters, where teams from different parts of the country can be accommodated and championship games will be played. Doubtless the " greens " under cover will be artificially lighted. There would seem no great difficulty in this—the problem is surely much easier than in the case of games in which the ball travels in the air and at high speed. Ample illumination and absence of glare and sharp shadows would seem to be the chief essentials. Here, therefore, is a good opportunity for enterprise on the part of firms in the lighting industry!

Floodlighting in Cathedrals

Floodlighting in places of worship is now becoming an accepted fact. The objection originally raised that it is " theatrical " is now less prevalent. Certainly it need not be so if only the contrast in brightness is kept within reasonable limits. Another useful effect of floodlighting is in revealing architectural features or decorations that might otherwise be overlooked—as, for example, in Westminster Cathedral, where mosaics, recently unveiled, have been floodlighted so that worshippers may see them clearly. There have been cases in which the introduction of floodlighting has revealed mural or ceiling decorations the very existence of which had previously been unsuspected! The " dim religious light " of the past was doubtless a necessary evil, which need not be perpetuated to-day.

Silhouette and Contrast in Display

Illuminating engineers are well aware of the dominant role played by the " silhouette-effect " in street lighting, a lesson which was strikingly illustrated by Mr. G. H. Wilson's experiment with the two cats, described in our last issue. The value of silhouettes, in the form of a dark object outlined against a bright background, is also familiar in display posters, where contrast plays an important part. In the case of an ordinary picture, illuminated from the front, a contrast-ratio much in excess of 20 to 1 is difficult to obtain. Hence a lantern slide is often much more striking than a picture, and a transparency lighted from behind more effective than an ordinary poster.

The Illuminated Background

There is, however, another way of using a modified form of silhouette, or of introducing contrast that is less widely practised—i.e., the use of a foreground behind which local light-sources are concealed, slightly in front of the main picture. The local lighting and the greater brightness it gives to the background scene helps greatly in giving life to the picture and creating an impression of distance. The idea is, of course, a familiar one on the stage, and is sometimes used with good effect in advertisements featuring scenery. An excellent example has been afforded by the series of charming pictures featuring Australia fitted up at the Charing Cross Underground Station, where numerous effective illuminated scenes of this nature have recently been staged.

TECHNICAL SECTION

COMPRISING

Transactions of The Illuminating Engineering Society and Special Articles

The Illuminating Engineering Society is not, as a body, responsible for the opinions expressed by individual authors or speakers.

The Illuminating Engineering Society

Notes on Recent Meetings and Events

THE ILLUMINATING ENGINEERING SOCIETY has been active during the past month. Besides the usual Monthly General Meeting held in London, a Special Meeting devoted to the subject of dock-lighting was held in Liverpool, on December 6. We understand that arrangements for further meetings in Manchester and other provincial centres are now being made. In what follows we give an account of both these gatherings.

The General Meeting held in London took place on December 6, in the lecture theatre of the E.L.M.A. Lighting Service Bureau, where members assembled for light refreshments at 6.30 p.m. The chair was taken by THE PRESIDENT (Mr. C. W. Sully) at 7 p.m.

The Minutes of the last meeting having been taken as read, the HON. SECRETARY read out the names of new applicants for membership, whose names appear below. The names of those announced at the last meeting were read again, and these applicants were formally declared members of the Society.*

APPLICATION FOR MEMBERSHIP.

Country Members:—

Daniel, R. W.....H.M. Inspector of Factories, Mappin Buildings, Norfolk Street, SHEFFIELD.

Hughes, K. M.....District Manager, Revo Electric, Ltd., 13, Ash Grove, Timperley CHESHIRE.

* ILLUMINATING ENGINEER, December, 1933, p. 295.

Forthcoming Events

Tuesday, **Jan. 9th, 1934**:—A paper entitled **Portable Lamps and their Applications** will be read by MR. A. CUNNINGTON, and will be followed by a discussion. The meeting will take place in the Hall of the Institution of Mechanical Engineers (Storey's Gate, St. James's Park, London, S.W.1) at **6.30 p.m.**

Tuesday, **Feb. 13th, 1934**:—**The Annual Dinner** will take place at the TROCADERO RESTAURANT, Piccadilly, London, W.C. **7 for 7.30 p.m.**

Tuesday, **Feb. 20th, 1934**:—A paper will be read by MR. H. BUCKLEY on **Heterochromatic Photometry.**

MR. BEUTTELL'S PAPER.

The President then called upon MR. A. W. BEUTTELL to deliver his paper, entitled "An Analytical Basis for a Lighting Code." The paper outlined a new method of computing values of illumination for various classes of work. After recalling the existing recommendations of this nature, which mainly represent what is called "good lighting practice," Mr. Beuttell referred to the work of the Technical Committee, which has been studying a new method of analysis originated by him. This method enables any visual task to be analysed in terms of contrast, visual size, and other characteristics that affect ease of vision. The requisite illumination is computed by applying in succession a series of multiplying factors. Various examples (clerical work, type-setting, and the lighting of tennis courts, advertisement hoardings, and drawing offices, etc.) were presented and dealt with in this way.

EXPERIMENTS.

The paper was illustrated by a series of striking experiments.

The author had explained previously how reflection factors influenced the visual task and how one of the chief factors determining the requisite illumination is the brightness difference between object and background.

The first experiment, accordingly, was designed to show how increased illumination may be applied to compensate for a low reflection factor. Black letters

were shown on a card, the ground of which was shaded, so that the reflection factor of the card, as seen by the observer, diminished progressively from right to left. In front of this card a shaded lamp was so stationed as to give unequal illumination, the card being illuminated at each point, so as to give equal brightness difference at that point between ground and detail throughout.

A second exhibit was prepared to demonstrate how far the illumination of a dark, or even a black, object may be taken to raise it to any brightness, or even apparent " whiteness." A black letter, " K," was arranged in front of a white ground. The reflection factor of the letter was 0.06, and the illumination provided by a spot-light upon it 700 foot-candles, making the brightness of the letter 42 foot-lamberts. Therefore, whilst this letter appeared black against a white ground equally illuminated, it should, Mr. Beuttell pointed out, appear *white* against a *black* background. By removing the white ground and substituting a black ground, the lecturer showed that the anticipated effect was produced. The contrast was reversed, and the black letter had become " white."

A third exhibit showed a card in which the six panels were prepared, all with an equal difference of reflection factor for ground and detail. The illumination was uniform all over the card. Therefore there was equal brightness difference in all the cards—or approximately so within the practical limits of sign-writing, although actually there was a little difference between the panels. The legibility appeared more or less equal in the five right-hand panels, but seemed to be definitely better in the left-hand one. This, the author thought, was due to the fact that the contrast in the panel is much higher than in the others.

The fourth exhibit was arranged to demonstrate the question of size. The letters on the card exhibited were graded in size, the smaller letters appearing on the darker background, so that two characteristics—contrast and size—varied simultaneously. Hence a relatively greater compensating illumination on the left-hand side of this card than in the case of the previous exhibit was needed.

Discussion.

At the conclusion of the paper there was a keen discussion, in which the following took part:—Dr. J. W. T. Walsh, Mr. G. H. Wilson, Mr. G. A. Masterman, Mr. H. C. Wheat, Mr. W. J. Jones, Mr. T. E. Ritchie, Mr. H. H. Long, Mr. M. W. Peirce, Mr. E. Stroud, Mr. J. M. Barnicot, Mr. A. Blok, Mr. F. C. Raphael, Mr. J. S. Dow, and Mr. A. Cunnington.

Mr. J. S. Dow mentioned that a desire had been expressed for the arrangement of a supplementary informal meeting at which the discussion of these fascinating problems should be continued. He asked any of those present who would like to attend such a meeting to communicate with him.

After Mr. A. W. Beuttell had briefly replied to various points raised in the discussion, a cordial vote of thanks to him for his paper and to the E.L.M.A. Lighting Service Bureau for their hospitality terminated the proceedings.

Mr. Beuttell's paper and the ensuing discussion will be found on pp. 5-16.

SPECIAL MEETING IN LIVERPOOL.

A Special Meeting of members in the North-Western Area was held in Liverpool on December 6.

This meeting was devoted to dock lighting, a subject of special interest to Liverpool. The actual meeting was preceded by a visit to the Liverpool docks. The weather was less auspicious than on the occasion of the recent visit to the docks at Southampton. It was dusk when the Gladstone Dock was at length reached, and it was only later that members whose trains had been delayed by fog were united at the entrance to the Mersey tunnel.

Lighting of the Mersey Tunnel.

This tunnel, which is to be opened next July, and is to be confined to vehicular traffic, proved well worth inspection. It is lighted on modern lines by means of incandescent lamps mounted behind panels of diffusing glass recessed in the walls of the tunnel. The actual illumination provided at the entrance is about 2 foot-candles. The spacing of lamps increases as the centre of the tunnel is approached. Lamps at the entrance can be switched off at night, so as to lessen the contrast in brightness on entering the tunnel, which is approximately 2¼ miles long.

Dock Lighting.

After adjourning for tea, the party, which included the President (Mr. C. W. Sully), Mr. J. S. Dow, Mr. T. E. Ritchie, and Mr. J. S. Preston, from London, foregathered in the showrooms of the Liverpool Corporation Electricity Department, where Mr. P. J. Robinson, the Liverpool City Electrical Engineer, presided. A practical and interesting paper on " Dock Lighting " was read by Mr. J. S. Preston, and a discussion ensued, in which Mr. C. W. Sully, Mr. Taplin (Mersey Docks and Harbour Board), Mr. Rogers, Mr. Midgeley, Mr. T. E. Ritchie, Mr. Sellars, and Mr. J. S. Dow took part. A cordial vote of thanks to Mr. Preston for his paper was accorded him, to the Mersey Docks and Harbour Board for according facilities for the visit, and to the Liverpool Corporation Electricity Committee for permission to hold the meeting in their showroom, terminated the proceedings.

In the course of the proceedings The President congratulated the local Hon. Secretary (Mr. James Sellars) on the success of the meeting. He added that preparations were being made for other gatherings, which he hoped would result in a substantial increase in the local membership.

Mr. J. S. Preston's paper on " Dock Lighting," and the ensuing discussion, will appear in our next issue.

An Analytical Basis for a Lighting Code*

A Method of Computing Values of Illumination for Various Classes of Work

By A. W. BEUTTELL, M.I.E.E.

(Chairman of the Technical Committee)

(*N.B.—The numbers in thick type and in parentheses relate to items in the List of References at the end of the paper.*)

TO every lighting problem there are two parts. The first is to say how much light is required to be provided; the second is to know how best to provide it. The first is to comprehend what we shall call the visual task and to assess the illumination necessary for its performance; the second is to design the best installation to furnish the intensity of illumination which has been chosen.

In this paper we shall not concern ourselves with the second part of the problem; it has nearly the whole of the science and practice of lighting behind it, but with regard to the first, there is a lack of ordered information as to the principles or working rules upon which an engineer may use his own intelligence in deciding the values of illumination required for various classes of work. His only source of information, apart from his own experience, is what is called a Lighting Code, that is to say, a list of such values which have been recommended by some body or other.

In Great Britain recommendations on the minimum intensities of illumination desirable for fine and very fine industrial work were included in the Third Report of the Home Office Departmental Committee on Lighting in Factories and Workshops (1922),† and in the well-known " Geneva Code " values of illumination for use in schools and factories, which have received international recognition, are specified.

In Great Britain, also, tables of recommended values have been frequently presented by firms in the lighting industry, and are embodied, for example, in a Handbook (2c) of the E.L.M.A. Lighting Service Bureau (**14**). No detailed statement of this kind has been issued by or under the auspices of the Illuminating Engineering Society. Recommendations on certain aspects of lighting have been made in the recently issued reports on the lighting of schools and libraries.‡ But in these and other cases it has been pointed out that the recommendations were based mainly on general experience, and the lack of an adequate scientific basis for such value of illumination has been emphasised.

Early in 1932, the Council of the Society decided to prepare a British Code and instructed its Technical Committee to undertake the necessary work. It was laid down that the values of illumination to be recommended should represent what is called " good lighting practice " and that a single value should be recommended for each class of work.

In approaching its task, the Committee naturally considered the method of procedure by which, presumably, Lighting Codes have been prepared in the past, namely, to collect all the evidence possible from actual practice and by experiment, and to select therefrom suitable values according to the judgment and experience of those engaged in the task. In the course of the discussion, however, the author ventured to propose a method which he had prepared in general principle It was based on the proposition that the illumination required for any visual task, as compared with the simplest possible task, depends upon certain conditions adversely affecting its performance; that these conditions can be defined; and that if the relationship can be ascertained between each of the conditions and the illumination required to compensate for it, then the illumination suitable for the performance of the task ought to be capable of actual computation. If this could be done, not only would the task of compiling the code be simplified, but it would be an advantage to the Engineer to be able to work out his figures for himself by taking the known conditions of the visual task into account and to interpret to some extent his own ideas of those conditions.

The Committee adopted the proposed method for investigation, and it stands at present as the one favoured for preparing the proposed Code, provided it can be shown to give sufficiently satisfactory results.

It is the purpose of the paper to offer it for discussion and criticism in its elementary form, reserving the experimental and scientific development for presentation at a later stage, when it is hoped that a further paper may be read.

ANALYSIS OF THE VISUAL TASK.

The conditions affecting the performance of the visual task may be enumerated under the following headings: Contrast, Visual Size, Movement, Period of Exposure, Glare, Adaptation of the Eye, Irradiation, Brightness of Surrounds, Shadows and Colour.

We shall not in this paper attempt to deal with all of these characteristics. The principle can be illustrated and approximate results obtained by considering only the more important ones. Their bearing upon Vision has been investigated by a large number of exponents, and a vast amount of data is available, though, unfortunately, it is mainly directed to obtaining results at the threshold of vision and not at normal levels of visibility. (See Appendix for list of references.)

For the information of those who are interested, there is an excellent summary of the work of all these investigators in a Report prepared by Mr. L. T. Troland for the Committee on Industrial Lighting of the National Research Council, U.S.A.*

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* Paper read at the meeting of the Illuminating Engineering Society, held at the E.L.M.A. Lighting Service Bureau, 2, Savoy Hill, Strand, London, W.C.2, at 6.30 p.m., on Tuesday, December 12th, 1933.

† Illum. Eng., July, 1922, pp. 197-203.

‡ Illum. Eng., July, 1931, pp. 157-161.

* Analysis of the Literature Concerning the Dependency of Visual Functions upon Illumination Intensity, Leonard T. Troland, Trans. (Amer.), Illuminating Engineering Society. February, 1931.

Contrast and Visual Size.

Let us commence by taking two only of the characteristics referred to, Contrast and Visual Size.

We give to Contrast its usual meaning and definition. We assume that the task can be broadly divided into two components, background and detail, of different brightnesses. Contrast is then expressed as a function of these two components. It is usually defined as the ratio of the difference in brightness to the brightness of the background, but we shall prefer to take it as the ratio of the brightness difference to that of the brighter of the two components, whichever that may be, ground or detail.

Since any brightness B is the product of the illumination E and the reflection factor ρ, the contrast $\frac{B_1 - B_2}{B_1}$ can also be expressed as $\frac{\rho_1 - \rho_2}{\rho_1}$, and therefore all functions of contrast can be dealt with in terms of the two reflection factors ρ_1, ρ_2, provided that both ground and detail are illuminated from the same source.

Visual Size is defined as the angle, in minutes of arc, subtended at the eye by any material detail of the visual task.

Principle of Compensation.

Now evidently the smaller the Contrast (**4** p. 15) may be, or the smaller the size (**4**. p. 7; **10**) of the object, the more difficult will be the task. On the other hand, it may be stated that the greater the illumination, the easier will be the task, although this statement is subject to limits. The one may compensate for the other so as to restore the desired degree of facility of vision.

The process we are about to describe really amounts to this, that we shall endeavour to take the visual task to pieces, assess its components, and put it together again in terms of the illumination required for its performance. The process is, however, entirely dependent upon our ascertaining the relationship between each of the conditions of the task and the illumination necessary to compensate for it. If we can do that, we can say how much illumination is required.

Basic Task.

To determine the relationship, we commence by fixing a standard or basic task, which shall be the simplest imaginable, performed under perfect conditions. For instance, let the task be adequately to comprehend a large, perfectly black pattern on a perfectly white ground, both the picture and the observer being stationary and let the illumination be glareless. The task will require a certain illumination for its satisfactory performance which we shall call the elementary, or preferably the Basic Illumination. By satisfactory performance, we do not imply the notion of a minimum, or of an excess, but rather of adequate illumination which we may characterise in the words of our original instruction and call it "good lighting practice."

Let, now, any one of these visual characteristics, which in the basic task are all as favourable as possible, be varied; the task will become more difficult and the illumination must be increased above the basic value to compensate for the change. In respect of any such change the increased illumination will depend upon the magnitude of the change, that is to say, there will be a relationship, wherein the required illumination will be a function of the variable, including the basic illumination as a constant factor.

Algebraically, if E_b be the basic illumination, E_w the working illumination and v the variable characteristic, then $E_w = E_b\, f(v)$ or $\frac{E_w}{E_b} = f(v)$.

MULTIPLYING FACTORS.

The ratio $\frac{E_w}{E_b}$ of the increased illumination to the basic illumination, therefore, represents a multiplying factor, f (v), so that if the Basic Illumination be multiplied by it, the product will be the Working Illumination necessary to perform the task with the specified degree of ease.

The factor is, as we have said, a function of the visual characteristic, and, if there is a definite and ascertainable relationship between the latter and the increased illumination necessary to compensate for it, the multiplying factor can then be numerically determined for any value of the variable.

Moving Vision.

So far, we have mentioned only two variables, Contrast and Size. Let us take another. Either the object or the observer, or both, may be moving; as, for example, when reading an advertisement from a moving train or examining articles on a moving conveyor; we shall refer to this as Moving Vision.

With regard to glare (**1**) it was decided to ignore this characteristic for the time being because it is a function of the lighting installation itself, and therefore only determinable after the latter has been designed.

We shall proceed, therefore, with the three variables: Contrast, Size, and Moving Vision, which are a group by themselves and submit to treatment to obtain equality of performance of the various tasks.

Emphasis.

To make our present list complete, there is a fourth factor, but it is not concerned with equality of performance, and, therefore, it was not mentioned in the previous list of fundamental characteristics. There are certain tasks which demand illumination, beyond that required for equal facility of vision, in order to obviate excessive strain or fatigue, for efficiency, to attract or compel attention, to make safety safer still, or for some other exceptional reason; for examples we may take difficult clerical or mechanical operations, illuminated advertisements, parts of moving machines endangering the person, or surgical operation tables. For this purpose it was necessary to add a factor which has been called the "Emphasis" factor. It is a multiplying factor, like the others, but it will be entirely arbitrary because it involves a psychological rather than a physiological relationship and therefore it is not capable of reduction to mathematical terms, at any rate for the present.

Table of Multiplying Factors.

Table 1. shows the characteristics with their factors. They are numerical ones and are only offered at this stage as being derived on an empirical or partly empirical basis. In fixing them, the first consideration has been that the results shall be in line with good lighting practice, but the factors for Contrast and Size also satisfy certain equations of relationship which have been suggested for investigation. In other words, there is an apparent agreement between empiricy and theory, which it is felt may lead to the discovery of the true laws of relationship.

For the time being the range of each characteristic has been divided into groups and a numerical factor assigned to each group. In all cases the factors on the left are unity when the conditions are approximate to those of the basic task, i.e., the best possible.

Contrast factors are arranged not under values of Contrast, but according to the difference of the two reflection factors of ground and detail (**8** p. 57). They are worked out so as to give a constant brightness

Visual Characteristic	MULTIPLYING FACTORS									
C CONTRAST	DIFFERENCE OF REFLECTION FACTORS									
	1·0—0·80	— 0·57	— 0·40	— 0·28	— 0·20	— 0·14	— 0·10	— 0·07	— 0·05	0
	1	1.5	2	3	4	6	8	12	16	20
S SIZE	VISUAL ANGLE IN MINUTES									
	10·0		4·0	2·5	1·8	1·4	1·2	1·0		
	1	1·5	2	3	4	6	8	10		
M MOVING VISION	RELATIVE MOVEMENT BETWEEN OBSERVER AND OBJECT									
	I None		II Slow		III Medium		IV Fast		V Rapid or Oscillatory	
	1		1·5		2		3		4	
E EMPHASIS	I None Required		II Close Attention		III Sustained Attention or Minute Examination		IV Surgical Operation		V Advt. or Spectacular Effect	
	1		1·5		2		3·5		† 1·5 (1+F) Min.	
BASIC ILLUMINATION E_b = 1·0 Ft.-CANDLE					†F=BRIGHTNESS OF FIELD					

EXAMPLE

		Contrast	Size	Moving Vision	Emphasis	Resultant Illumination Ft.-Candles
Clerical Work	Group	0·57—0·40	4·0—2·5	I (None)	II	E_w
	Factor	2	2	1	1·5	6

TABLE I.

Multiplying Factors corresponding with Contrast, Size, Moving Vision and Emphasis.

TABLE II.

Examples, illustrating how the Multiplying Factors listed in Table I. may be applied.

TABLE OF EXAMPLES (BASIC ILLN.—1·0 Ft.-Candle.)

TASK		CONTRAST	SIZE	MOVING VISION	EMPHASIS	RESULTANT ILLUMINATION Ft.-Candles
Clerical Work	Group	0·57—0·40	4·0—2·5	I (None)	II	6
	Factor	2	2	1	1·5	
Type Setting	Group	0·28—0·20	1·8—1·4	I (None)	II	24
	Factor	4	4	1	1·5	
Surgical Operation	Group	0·05—0	Less than 1·0′	I (None)	IV	700
	Factor	20	10	1	3·5	
Corridor	Group	0·57—0·40	Larger than 10·0′	I (None)	I (None)	2·0
	Factor	2	1	1	1	
Tennis Court	Group	0·40—0·28	More than 10·0′	V (Rapid)	III (Sustained Attention)	24
	Factor	3	1	4	2	
Advertisement Hoarding from Train	Group	0·40—0·28	Large	III or II	V	Near 9·0 Distant 6·75
	Factor	3	1	2 or 1·5	1·5 (F-0)	
Drawing Office	Group	0·40—0·28	1·8—1·4	I (None)	III	12.0
	Factor	3	4/2=2	1	2	

difference equal to that of the basic task. The factors range from unity to a maximum of 20 as a practical limit.

Size factors range from unity up to a maximum of 10, which actually corresponds to a minimum of one minute of arc (**8** pp. 36-37), or a size of about 4/1000th of an inch at the standard focussing distance of 14 inches.

Progressive Multiplication of Factors.

If now, more than one or all of the characteristics, C, S, M and E be changed simultaneously, the corresponding factors are multiplied together, to obtain the resultant multiplying factor. In saying this we are assuming for the moment that once we have established a system of variable factors, each of which is true for the variations in its own particular characteristic when the latter is taken by itself, then they will be true for variations in the whole combination of characteristics when they are all multiplied together. This may or may not be strictly true. It is a point that requires an investigation which should not be difficult, but the most likely assumption is that the principle of the progressive multiplication of factors will hold good, and therefore we shall proceed accordingly.

The table is, therefore, applied by assigning the given task as falling within one or other of the groups of each characteristic, selecting the corresponding factor of each group so chosen and by multiplying all of the factors together. The result will be the multiplying factor for the whole combination, and the product of this and the basic illumination E_b will give the required working illumination E_w. For this time and this country a value has been selected of one foot-candle for the basic illumination E_b.

EXAMPLE OF CLERICAL WORK.

In the example given for Clerical Work the factors have been chosen as follows:—

Contrast. A fair average reflection factor for paper is taken as 0.65, and for print or typed matter 0.2. The difference is 0.45, and the multiplying factor for this characteristic is 2. Size has been taken as 3.9 minutes for 8 point type, which is the smallest type commonly used. The factor is 2. Moving vision does not apply, because all reading operations are classed as stationary, provided there is no relative movement between observer and object. For emphasis, we select a factor of 1.5, denoting close attention. We, therefore, arrive at a result of 6 foot-candles.

BASIC ILLUMINATION.

It will be observed that once the basic illumination has been fixed it will govern the whole range of values. This makes for a certain flexibility in the system. The general level of illumination not only changes as the public demand for light increases but it varies in different countries. This general or average level of illumination can, therefore, be met by the proper selection of the basic factor, and its amendment from time to time.

FURTHER EXAMPLES.

We shall now consider some further examples (Table II.) with factors taken from the Table I, and in doing so we shall discuss any points of difficulty as they arise and lay them open for discussion and criticism

We shall experience at first some little difficulties in choosing our factors, or rather in selecting the groups from which the factors are to be taken. In the case of Contrast, for example, reflection factors must be assigned so that the correct group may be chosen. In some cases this can be done without difficulty, but in others discretion must be exercised in deciding what are the material elements of the task. It would be proposed to include in the text of a code, not only a full explanation of the principles on which the method is based, but comprehensive notes, data and references to guide the designer in this and any other matters presenting any difficulty.

The examples appearing in Table II. are not presented as infallible examples of good practice; nor should it be assumed that factors such as will satisfy all cases completely have yet been found. Our next task will be to study all such details and to effect improvements where necessary.

Typesetting.

Contrast: We imagine type which has to be selected from a type case. We may judge the contrast to be as one of bright cast-iron, with shadows on dull metal in the cavities and some specular reflection from the face of the type. The reflection factor difference or R.F.D. would be found from tables of diffuse reflection factors which would be provided. In this case the reflection factor is 0.28 for the bright metal (**8** p. 57), and as the high lights and shadows play a definite part in the visibility, the author has selected an arbitrary R.F.D. of 0.23. The multiplying factor is, therefore, 4. It should be noted that when specular reflection from metallic surfaces is employed in the visual operation one must not depart greatly from the diffuse reflection factor, because mistakes probably occur at the moment when specular reflection is assisting the least.

Size is for 6-point type,† 1.7 minutes; factor, 4.

Emphasis is for close attention. The result, 24 foot-candles, may be compared with the value, 20 f.c., recommended in the Report of the Industrial Fatigue Research Board and the Illumination Research Committee of the D.S.I.R. in 1926.

Surgical Operating Table.

Maximum factors have been selected. Both Contrast and Size may evidently be a minimum in a wound, and for Emphasis there is a special group for these and similar operations involving the risk of life. The result is 700 foot-candles. It may not in all installations be attainable, but it indicates the desirable level, and it is one which has been very nearly reached in practice with the best results.

Corridor.

The Contrast factor taken from the range of R.F.D. 0.57 to 0.40 represents a fair conception of the contrasts which are presented to the eye.

It is found that, with a little experience of the method, it is not always necessary to allocate precise reflection factors to the details of the task. Contrast as a ratio $\frac{\rho_1 - \rho_2}{\rho_1}$ does not figure in the calculations. The basis is the R.F.D., or $\rho_1 - \rho_2$, in other words, the fractional difference between dark and light details, and this difference can often be assigned within the necessary limits by merely visualising the details of the task which are material to the visual operation.

Otherwise the case calls for no further comment save that the system yields a reasonable result, 2.0 foot-candles, at the lower end of the practical scale.

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† This footnote is printed in 6 point type.

TENNIS COURT.

Contrast: Reflection factors are taken as 0.5 for the ball and 0.15 for the average of sky and non-illuminated background at night. Difference 0.35. Factor 3.

The size of a ball approaching a player would be more than 10 minutes. Size factor 1.

Moving Vision is placed in the fifth group. Factor 4.

Emphasis is for sustained attention. Factor 2.0.

The result is 24 foot-candles.

In practice the figure would be applied as for vertical illumination, because the line of sight is mainly horizontal, or slightly upwards.

The system gives 13.5 foot-candles for a football ground.*

ADVERTISEMENT HOARDING.

This example raises the question of colour, and, therefore, we may digress a little to consider it.

No attempt has been made in the paper to formulate rules or constants to provide for colour differences. The sensation of contrast which the eye experiences between two colours which may be of equal brightness is a subject to itself, and it must be included in our further researches and eventually brought into line as an integral part of the main subject.

In the meantime it may be said that reflection factors have been assigned in terms of the percentage of light that would be reflected from coloured surfaces. Such reflection factors would affect the contrast, but only in part, because the multiplying factor would also be a function of the contrast equivalent of two colours of equal reflection factors. The combined relationship therefore requires to be determined.

There is probably not much difference between the illumination required for a multi-coloured poster and a self-coloured one. The engineer may make some allowance in favour of the multi-coloured task if he pleases, but if he applies the method as for neutral greys he will be on the safe side.

On these lines an R. F. D. has been selected of 0.3 for the least contrast likely to be used by a good poster artist. The Contrast factor is, therefore, 3.

The size factor is unity, size of detail being assumed to have been selected by the artist large enough for good visibility.

We will assume that the hoarding is to be viewed from a moving train. We are, therefore, concerned with Moving Vision. Alternatives are given according to whether the hoarding is near to the observer and the angular speed is medium or far away, when it would be slow. The factors are 2 or 1.5, showing that an observer, for instance, viewing an advertisement near to a moving train would require it to be brighter than a distant one.

Coming to Emphasis, there is the important question of Surrounds, by which is meant the whole of the visual field surrounding the task. So far as Acuity is concerned—i.e., the ability to distinguish detail, once the eye is focussed on the task, the optimum condition is probably that the surrounds should be equal in brightness to the task. Anyhow, this is true at the threshold. But in the case of an advertisement, the whole of it must be much brighter than the surroundings in order first to attract attention to it. This is the true Emphasis effect, and it is definitely a function of the brightness of the general field. We find that a multiplying factor 1.5 $(1+F.)$ where F. is the brightness in foot lamberts of the general field gives results agreeing with good practice. It would mean, in the present example, if the observer were stationary, that a hoarding would need 4.5, 13.5, or 49.5 foot-candles according as it were placed in a dark locality such as a field, or in a locality illuminated to 2 foot-candles or in an exhibition at a general level of 10 foot-candles.

But if the observer were in a moving train, the figures for the field location would have to be multiplied by 2 or 1.5 according as the relative movement was medium or slow, giving the result 9.0 and 6.75 foot-candles respectively.

DRAWING OFFICE.

Contrast has been reckoned on the basis of tracing from pencil drawings through tracing cloth and the R.F.D. has been taken as 0.3. Factor 3.0.

With regard to size, we shall divide the size factor by 2 when it is based on the width of a line. The size selected is 1.6 minute, and the nett factor is 2.

It must not be overlooked that, given a small circular object and a line of equal diameter and width respectively, the visibility of the line is the greater. Therefore, in some tasks—e.g., the drawing office, the multiplying factor requires some modification when the visual width of a line is taken as the basis of size. The precise rule of working requires to be established, but for the present purposes the factor will be halved for line vision. It could be said, of course, that points also occur in drawings, but it is suggested as a general principle of this method, that when the predominant feature of a task requires a given illumination, and the most exacting operation can be performed under that illumination with a momentary extra effort, the basis of calculation shall be the former and not the latter.

CHOICE OF FACTORS.

An aspect of the method which is open to criticism is that two engineers with the same problem to solve may quite easily select different factors from the table and arrive at different results. But it should be borne in mind that if the factors have been chosen with due thought and care, the difference in the choice is not accidental, nor necessarily misleading, but is due to the fact that the two engineers are taking different views of what is required, and therefore naturally, and maybe quite rightly, obtain different results. There is a flexibility in the method which is denied to them in the use of a fixed code.

The factors in the Table have been chosen so that on what appears to be the most reasonable selection of them for a number of well-known tasks (to which "good practice" values can be safely assigned) the results would appear to be reasonably satisfactory.

The first object of preparing this method was to assist in compiling a code in which it was laid down that the results should represent current practice. It is not believed that these figures are consistent with the criterion of equal facility of vision in all tasks; in fact, experiments which have been made indicate firstly, that current practice falls short of the criterion of equal facility as regards the more difficult tasks, and secondly, that in the most difficult of them equal facility is, in fact, unattainable.

If and when, however, factors can be found which are true for a sufficiently large and varied number of tasks as carried out by actual practice, then it is suggested as axiomatic that the factors will be true for all the others.

It is not pretended, however, that the Table cannot and will not be improved upon; that is our present task and the object of all further investigation and experimentation. There is no reason, in the meantime, to prevent any engineer from trying out the Table for himself and making such modification in it as he pleases for his own personal use.

* There is a football ground at Huron College, S. Dakota, where the illumination, presumably a minimum, at the centre of the field is 9.5 foot-candles. Am. I.E.S. Lighting Data 21-2.

OTHER VISUAL CHARACTERISTICS.

All of the examples already shown have been worked out on the basis of the four main characteristics, Contrast, Size, Moving Vision, and Emphasis. What of the other characteristics which were mentioned earlier in the paper? One of them, Colour, has been dealt with under the example of the Advertisement Hoarding. The remainder are as follows: Period of Exposure, Glare, Adaptation of the Eye, Irradiation, Brightness of Surrounds, and Shadows, although the latter was referred to in Typesetting.

They have been set aside partly for the sake of simplicity, partly because the effect of some of them on the problem in hand requires further investigation before we can offer any working rules, and also because, within the limits of their likely effect upon the results, the other factors could be so chosen that they would suffice for the purposes of this paper. If and when they are brought into our calculations, however, the present factors will doubtless undergo some degree of modification.

It may be interesting to consider them very briefly:

(1.) Period of exposure (**2**) is the time during which the object is visible. It does not enter into our calculations unless the period is very small (less than 1-10th second), even under exacting conditions of size and contrast (**8.** Ch. vii.), and therefore for most practical tasks it can be ignored.

(2) Glare (**1**), as has been noted already, was eliminated for the time being because usually it is a function of the lighting installation itself. In some cases, however, as, for example, in an advertisement hoarding, there may be light sources in the field of vision not under the control of the engineer. As another example, veiling glare (**1.** p. 222) is present by reflection of the interior when looking through the windows of a lighted railway carriage at such a hoarding in dark surroundings. The subject must be explored, but its omission does not seem to have led to erroneous results.

(3.) *Adaptation* (**4,** p. 19; **8,** Ch. 10; **10,** p. 49) is the alteration in the sensitivity of the eye depending upon the brightness of the visual field; it may be considered to be already taken care of in our calculations, provided that we have been calculating for a general illumination, or, alternatively, with general plus local illumination, that the brightness of the surrounds has been taken into account. This, however, will be referred to later.

(4.) *Irradiation* is the phenomenon by which bright objects appear larger than they really are. It accounts partly for the fact that in general white objects are more distinguishable on a black ground than vice-versa (**6**), although there is an exception to this, namely, in reading small print. For example, the distinguishing of the letter C from O is a question of the visibility of the gap in the C. The white ground extends to form a break in the black line forming the letter, which break is capable of being enlarged by irradiation. Irradiation does not, however, import any considerable complication into our problem for the present. It enters more into the field of luminous objects.

(5.) *Brightness of Surrounds*: By this term we mean the whole of the area of the field of vision surrounding the visual task. Acuity is probably a maximum when the brightness of the surrounds is equal to that of the task. High contrasts of task and surrounds are inimical to the best vision, but only seriously so when the surrounds are much brighter than the task itself (**10,** p. 20). When they are darker the effect on acuity is probably negligible, and as the former contingency is more or less remote, the question does not seem to be of serious importance for the present, save for advertising or spectacular effects, which have already been dealt with. It would, however seem to indicate that for sewing dark materials, for instance, local illumination should be provided so as to keep the surrounds as dark as possible. Light materials would be best done under a general illumination.

(6.) *Shadows*: In distinguishing the details of a visual task, shadows often play a part as important as that of different reflection factors. This is particularly so in the case of white or unicoloured articles of homogenous surface or texture as, for example, a bas relief, or the face of a building which is to be flood-lighted, or examining or sewing articles of linen or other fabrics. By shadows are meant the shadow cast beyond the article, or the darkness of that part which receives no light from the main source, or, again, that of those parts which receive light but owe their shading or darkness to the angle they present to the source.

In these cases Contrast becomes a function not of reflection factor, there being no difference at all, but of its equivalent in differences of illumination or cosines of angles of incidence, as the case may be. If these be substituted and read as the reflection factors shown in the tables it is suggested that the problem can be worked out by the method, provided that the uniform reflection factor of the surface be taken into account (by multiplying by its reciprocal), and also the cosine of the angle of incidence on the main surface. The result will be given in terms of the illumination on the main surface.

Suppose we have to floodlight a building as follows:—

Reflection factor = 0.35.
Emphasis factor if surrounds be zero = 1.5.

The equivalent Contrast factor will be $\frac{1}{\rho}$ in order to make the brightness difference between zero shadows and the face of the building equal to that of the basic task, i.e., unity.

Therefore, the required illumination is:

$\frac{1}{0.35} \times 1.5 = 4.3$ foot-candles, assuming that no allowance is required for size of detail or extra-spectacular effect.

The most economical condition is when the same brightness difference exists between the face of the building and the high lights. If the latter be taken as those on surfaces normal to the source, then the most economical angle of incidence will be 60°.

If the angle of incidence on the face of the building be greater than 60° then the equivalent factor for contrast becomes

$$\frac{\text{Cos } \theta_F}{\rho(\text{Cos } \theta_P - \text{Cos } \theta_F)}$$

Where θ_F = angle of incidence on face of building.
,, θ_P = angle of incidence on projecting part.

CONCLUSION.

The foregoing part of the paper has been devoted to a description of the method, so far as it could be given in its present or tentative stage.

Let us now pass to the part which has been taken in this matter by the Technical Committee of the Society and a Sub-Committee which it appointed to investigate and report on the practicability of the proposals.

Once the Committee had adopted the method for investigation and development, it became a corporate

work, and the author desires to acknowledge his indebtedness to these gentlemen for invaluable advice and generous assistance, and especially to the following members who comprise the Sub-Committee:—Messrs. H. Buckley, J. S. Dow, W. J. Jones (Chairman), C. A. Masterman, T. E. Ritchie, Dr. J. W. T. Walsh and Mr. H. C. Wheat.

Acting on the report of its Sub-Committee the Technical Committee advised the Council in December last of its opinion that the proposals represented a reasonable basis for establishing suitable values of illumination.

It also added to its report the following:—" In view of the limited knowledge of visual performance and its correlation with various elements, especially under conditions other than threshold, the Committee feels that for the present it may be necessary to assign to the elements values which have been derived partly on an empirical basis. The small amount of research carried out on Illumination Values under working conditions also adds to the present difficulty of the Committee in producing a table on a fundamental basis, and in fixing the values of the elements, the Committee feels that it should be guided by the results obtained agreeing with good present-day practice in certain well established cases."

The Committee concluded its report by expressing the hope that some research might be undertaken by the Department of Scientific and Industrial Research on " the Illumination Values necessary for equal facility of vision under practical conditions."

It will be appreciated that the chief difficulty lies in the fact that whilst vast quantities of work have been done and recorded on the relationship of the visual characteristics and their influence on illumination, it has nearly all been directed to results obtained at the threshold of vision. It is, therefore, of little value for the present purpose, because if a law of relationship between two variables be established at the threshold, it by no means follows that the same law will hold good when practical values are assigned to all of the variables. It is for this reason that considerations of Fechner's law, for the purposes of this method have proved disappointing. Thresholds, however, do occur in practice in special cases. For instance, when detecting minute flaws in metallic surfaces which may or may not escape observation, we are on the threshold of size. Or when matching materials, we are on the threshold of contrast or colour difference; but one must be wary of drawing general conclusions from threshold data.

Members will be pleased to know that the Illumination Research Committee of the Department of Scientific and Industrial Research has been considering the initiation of experiments of this nature; that a Sub-Committee appointed for the purpose of preparing a suitable scheme of work is already in existence, and that it will have the benefit of the assistance of the Committee on the Physiology of Vision of the Medical Research Council, who have already done so much valuable work on that subject.

In researching for equations of relationship, the object is not only to ascertain thereby what the numerical multiplying factors ought to be, but to be able to state a single expression as a function of the variable, so that we may simply substitute for any value of the variable, and avoid dividing its range into arbitrary groups, each of which has now to be satisfied with a single value of the multiplying factor. The chief objective, therefore, is the substitution of functional derivatives of the variable characteristics for the empirical and numerical multiplying factors.

There are many aspects of the method which call for attention.

There is, for instance, the question of the progressive multiplication of factors. If a visual characteristic v_1 varied by itself, requires the basic illumination to be multiplied by a for equal performance, and characteristics v_2, v , similarly require multipliers b c, if all be varied together, will the correct multiplier be $a\ b\ c$? There were some doubts expressed in Committee, but the difficulty is one which should be solved by the experiments which, it is hoped, will be carried out by the D.S.I.R.

Again, in seeking to establish equations of relationship, is the criterion of equal facility of vision a workable basis? It may be that such a criterion is unattainable, and that in very difficult cases no amount of illumination will provide facility equal to that of the basic task. If so, the practical limits of approximation to equality must be ascertained and placed within the range of the method.

Should the work which remains to be done enable us to set up mathematical relationships which would provide factors supported by scientific reasoning and experiment, it would seem that an advance will have been made, not only for the purpose of these proposals, but in the scientific equipment of the industry.

For the reason that human vision cannot function without light, the ultimate objective is scarcely less than the reduction of the physiology of vision to a scientific and mathematical basis. In this light, the author feels that no amount of apology for the defects or inadequacy of a tentative paper on the subject could meet the case.

His present objective, however, was no more than to start something moving in the direction of a practical solution of the problem of recommended values, which must be established upon a satisfactory foundation of first principles before they can be made subject to any form of ordered and scientific reasoning.

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An Analytical Basis for a Lighting Code

DISCUSSION

Dr. J. W. T. WALSH in opening the discussion said that all must agree that Mr. Beuttell had done signal service to the Society and Illuminating Engineering as a whole in presenting the ideas described in this paper. Although, as the author had mentioned, various other members of the Technical Committee had helped in the development of the methods, he thought that those of them who were present would endorse his (Dr. Walsh's) statement that the origin of the whole thing, as well as much of the working out, was entirely due to Mr. Beuttell himself. If this scheme fulfilled the hopes of the author and of those associated with him in its development, it would be taking a very big step towards putting illuminating engineering on a sound scientific and fundamental basis.

Dr. Walsh said that Professor Hartridge had used as an analogy the conditions of the past when photographers had no exposure meters, each one relying on his own personal experiences. One could now do better as trustworthy devices enabled one to read off the correct exposure. The object of Mr. Beuttell's scheme was to place illuminating engineers in a similar position. If a device of this kind could be provided a very great service would have been done to those interested in good lighting.

In regard to the proposed research work of the Department of Scientific and Industrial Research, it should be explained that authority had not yet been given by the Advisory Council, and the work naturally could not be initiated until this matter had been considered by them. He noticed that Mr. Beuttell had modified the wording of his paper, bearing this point in mind. Dr. Walsh said he would like to make one suggestion: on reading through the paper he thought that there might be some confusion in connection with the tables giving the factor termed "Contrast." It was not clear that the figure placed above the multiplying factors did not actually represent contrasts, but rather the contrast taken together with the reflection factor.

One other point of interest to him in the paper was the question of the relationship between shadows and contrast, for example, in connection with type-setting. Mr. Beuttell assumed certain reflection factors for type, and others for recesses in the type. If, however, a very diffused light was used, would the factor for contrast be raised to 20? It might be that this scheme would one day provide a guide as to the amount of diffusion to be desired in the light provided for any given process. It was only by the collection of the opinions of illuminating engineers in all branches of the science that the whole idea could be tested and its usefulness demonstrated.

Dr. Walsh concluded by remarking that this was a wonderful piece of work and he would like to thank Mr. Beuttell very much indeed for having brought it before the meeting.

Mr. G. H. WILSON wished to congratulate Mr. Beuttell on devising such an excellent method of getting out a Lighting Code for Illumination values, and one which was of great promise. He hoped that this work would be continued as quickly as possible. In his view experiments should certainly be made to elucidate points of difficulty, but he thought the matter should not be held up unduly for these investigations. Many existing Lighting Codes had a very insufficient fundamental basis; they rested mainly on the opinions of a number of experts on illumination, and it was not possible to confirm their views by experiments in all cases. The method of preparing a Lighting Code that Mr. Beuttell had suggested did seem to furnish a much more logical basis, and was probably at the moment as sound as many of the values in published codes.

He observed that Mr. Beuttell had taken a basic illumination of one foot-candle. It was, however, possible that illuminations of less than one foot-candle might sometimes be adequate, and it would be seen that the tables gave no guide to the assessing of such values. Mr. Wilson asked what provision could be made for such cases by the Beuttell's method.

One further thought was whether there was any relation between this schedule and Street Lighting? If the schedule was applied to Street Lighting and one foot-candle was taken as a minimum basic illumination required at the B.S.I. test point, this would mean in fact that only streets in Classes A and B received even the basic illumination; this surely would illustrate the deficiences of Street Lighting at the present time.

Mr. C. A. MASTERMAN said he would like to echo Dr. Walsh's remarks in attributing the great credit of this new system to Mr. Beuttell, and he looked forward to the "Beuttell Method" becoming the accepted phrase among illuminating engineers.

Naturally, such a system presented difficulties, and the Committee members, when applying it to test various illuminating problems, achieved very different results, and the greatest care was required in defining the factors to be used. There was a doubt even in deriving the simplest factor of size, whether, for instance, on a greyhound racing track the unit of size was going to be the dog or the dog's leg! Work on a lathe presented a difficult problem in definition of the factor for movement. Confusion might also arise when deriving illumination values for positions such as a clerical office where a number of tasks were carried out. Quite incorrect values were obtained if the various factors were derived for the most adverse condition in the office; e.g., by combining the smallest print in use with the contrast factor for coloured invoices and the emphasis factor for adjustment of typewriter and exaggerated figures for the illumination might be obtained. Each task must be considered separately.

The fact that there were difficulties did not militate against the value of the method. Discussion and diverging views among illuminating engineers would not be abolished, but would be placed on a logical and scientific basis. For this, great credit was due to Mr. Beuttell.

Mr. H. C. WHEAT likewise wished to congratulate Mr. Beuttell on his paper, and the form in which it was presented; also to endorse what had already been said in regard to its usefulness. The author of the paper was entirely responsible for the idea it presented, and anything the Committee might have been able to do in no way detracted from the credit due to Mr. Beuttell.

At the present stage the scheme should not be criticised too severely. He would like to suggest that the data presented might be regarded as a machine—a great deal depended upon the judgment with which it was manipulated. We had yet to gain the necessary experience to use it correctly.

Mr. W. J. JONES said he would first like to record his great appreciation of the paper. Mr. Beuttell should take full credit for all that had been done. This method had only just been initiated, and the paper, apart from its ultimate view, served to give a deeper insight into the intricate problems discussed. He hoped

that Mr. Beuttell would give further information on the contrast factor to which Dr. Walsh had already referred. He thought that it was perhaps a little unwise to consider the difference in brightness as dealing with the reflection factor and contrast. More experiments would naturally be needed in order to get a fundamental basis for the future. He (Mr. Jones) wanted to see these factors established on a fundamental and scientific basis, and hoped that this would be possible before very long. One point that he would like to emphasise was that as much care must be taken in the application of these factors as in their derivation. Much confusion might be caused by a person wrongly interpreting what was merely a simple task, and it would be best, therefore, to confine interpretation to tasks of simple character. In conclusion, he would like to recall that the preparation of this paper was the result of a request addressed by the Council to the Technical Committee of providing a Lighting Code. We must, however, perfect the proposed method before we could proceed with the preparation of this code, and until that stage was reached it was best to adhere to existing codes which are based on good practice and experience. He joined with other speakers in congratulating Mr. Beuttell both on the preparation of his paper and on the interesting experiments he had shown.

Mr. T. E. RITCHIE stated that the previous speakers had left him very little to say. In congratulating Mr. Beuttell he would like to say that he looked upon his achievement as a fundamental piece of thoroughly sound British work. So much had been done abroad in the framing of lighting codes that he felt that the members of the Society should all feel proud that the preparation of this new method had been done in this country. He was glad that Mr. Beuttell had had the courage to introduce such contentious subjects as tennis and football. He himself had been concerned in the making of a good many experiments in this connection, and thought that, judging from current practice, the intensities given in the paper for the lighting of football pitches were too high. This did not, however, necessarily mean that the method was wrong. It might well be that its application was faulty or incomplete, that current practice was mistaken, or that economic considerations prevented the ideal being attained. It was, in fact, economically impossible at the present time to get people in this country to consider so high a value as had been suggested by Mr. Beuttell for the illumination of football pitches, although having regard to the intensities under which the game was played by daylight his figure was probably more in line with actual requirements than the materially lower intensities normally provided.

Mr. Ritchie also stated that he was very glad that the Society had decided upon the publication of the suggested method at this stage, and notwithstanding its present incompleteness, because with the information furnished by the paper it would be possible for any illuminating engineer to try out the method by himself. He hoped that many of those present would do so, and more especially that, having worked out a number of examples they would communicate their results to the Society. The members of the Committee dealing with the matter were anxious to secure as much information as possible, and he was quite sure that such data would be welcomed.

As regards the preparation of a new lighting code he agreed with Mr. Jones that, before embarking upon any radical change, one must be particularly careful to see that the new method was fundamentally sound, and that everything was complete and foolproof, and he felt therefore, that before any change was made in the present Codes the new method should be thoroughly proved and tested. Subject to this he would welcome its introduction and widespread adoption.

Mr. HOWARD LONG said he would like to congratulate not only the author, but the Committee, on breaking new ground and taking members of the Society into their confidence at this early stage. This, he thought, was a compliment to the members of the Society in trusting them not to pull to pieces a piece of incomplete work. He assumed, however, that the object in reading the paper was to invite suggestions and constructive criticisms from members, although the author carefully disarmed his critics both at the commencement and termination of his remarks.

The first thing to be borne in mind, therefore, was in what form should these data be presented, and for whom were they intended?

The final form should give a table of illumination values in similar form to that at present used in various handbooks. It could include other matter dealing with the method and giving brightness—difference ratios and size factors, for the man who had time to use them. Life was short, however, and it would not be possible to use the full method for every lighting scheme, even if sufficient information were received. It would be very difficult to obtain in the usual case sufficient information to operate the method. On the other hand, it would be of distinct value to have a table giving foot-candles required for different classes of work which had been calculated on a scientific basis instead of being derived from what was usual practice.

In addition to the four factors used in the method C, S, M and E, Mr. Long remarked that there were many others which affect the value of a lighting installation. Some of these had been mentioned by Mr. Beuttell in the paper, for instance:—

(1) In some visual tasks, *shadow* is essential before they can be performed.

(2) Some objects are *self-luminous*. How this would be dealt with needed careful consideration.

(3) *Glare*, which had been mentioned in the paper but dropped by the wayside temporarily, must be considered although a result of the installation itself. By glare here was meant the effect of the lighting installation on the pupil of the eye. For instance, a totally indirect system gave surfaces of low brightness, and enabled the eye to open to its fullest extent and function most efficiently, whilst with an installation of totally enclosed diffusing fittings there was a degree of brightness from the fittings themselves which contracted the pupil to a certain extent, and thus made the visual task more difficult.

(4) *The system of lighting*—i.e., Direct, General, Indirect, etc., which was bound up with (3) to a certain extent, had to be considered.

(5) *The colour of the light* itself as distinct from the colour of the object to be seen (mentioned in the paper) was of importance. It was only possible to perform some visual tasks under a certain colour of light.

(6) Allowance must be made for *defective sight* in view of the fact that a very large percentage of the population suffered in this respect; what was satisfactory for those with A1 eyesight was totally inadequate for those whose sight was not up to the highest standard.

(7) Having determined how much light was just adequate to enable a task to be performed satisfactorily, it was necessary to add *a factor of safety* (what Dr. Luckiesh calls " humanitarian foot-candles "), so that the eye was not working at the full load all the time. This might in some measure be covered by the Emphasis factor already included in the method, but whether this was so was not clear.

(8) It was noticed that the *basic illumination* was taken at 1 Ft.-C. It should be pointed out (and Mr. Long did not think he was giving away any secrets in saying this) that an investigation, the results of which would probably be published shortly, showed that in an operation

where no visual task was entailed (the work could be done in the dark), it was found that the best results were obtained only when the illumination was increased to 5 Ft.-C. With anything less the production fell off. The inference seemed to be that in order to obtain full benefit from the psychological reaction to cheerful, well-illuminated surroundings, 5 Ft.-C. was necessary as a minimum.

Mr. M. W. PEIRCE said that he was much interested in the paper and wished to thank the author and the Society for putting it before them at this early stage. They all knew the class of person who did not believe in scientific methods, but rather preferred the rule of thumb methods. It was too much to hope that this system could become as simple as a foot rule. He hoped, however, that it would be made as simple as possible, and presented in a form capable of explanation to a user of light.

If one suggested a certain value of illumination, say, ten foot-candles to a customer, one was sometimes asked why five would not be sufficient.

He thought the system as applied to floodlighting was unduly complicated. The task of the illuminating engineer was to make the building stand out from its surroundings, and if the intensity was calculated on the basis of this contrast there would of necessity be sufficient intensity for contrasts on the building face itself.

On the other hand, the application of the system to a drawing office was more simple and made it possible to give definite reasons for using a higher intensity here than in a general office.

On referring to the tables he was surprised to find one of the emphasis factors named " Surgical Operations "; this was a departure from the general nature of the remainder of the tables, and, in his opinion, from one of the principles of the new method.

Mr. E. STROUD said that he found some diffidence in discussing the paper, owing to the fact that he had not studied the suggested theory of Mr. Beuttell. Therefore, it was hardly fair to criticise points which no doubt had already been appreciated by the author. Obviously, there had been an immense amount of work put into the paper, and all credit was due to Mr. Beuttell in putting the idea of a Basic Lighting Code forward.

There was no doubt as to the value of such a Code if it was practicable and could be proved scientifically sound. Previous recommendations on illumination had, he presumed, been based on collective experience, and in some cases definite investigation, but probably without any mathematical basis. On the face of it, it would seem extremely problematical whether sufficiently accurate definite factors could easily be allocated to the various functions which go to make up " seeing ability."

Another practical query was whether in the ordinary way one would be in a position to obtain all the necessary factors regarding a specific installation before working out a scheme.

Again, in this general connection, if one had the necessary contrast and other factors to work to originally, one must appreciate that although a lighting installation was more or less permanent, the articles contained in the particular area to be illuminated might, and in many cases did, change very materially during shorter or longer periods. This would mitigate against accurate factor calculations, as one would need to allow in calculations for the worse conditions.

He wondered whether Mr. Beuttell's factors were based on actual reflection co-efficients for the cases reviewed. He had compared the values given in the tables with those given in existing Codes, and had found that on the whole they gave good agreement. One wondered, however, what would happen if Mr. Beuttell's foot-candle recommendations came out twice as much as those in general use and considered adequate!

Recommendations must, of course, be adequate for the particular class of work, but one must harmonise the illumination factor with the economic factor. Street lighting, for instance, would not be the problem it is, but for the fact that the economic factor was invariably present.

He had read and listened to the paper with great interest and sincerely hoped that definite simple factors, which will form a definite basis for illumination requirements, would be evolved.

Mr. J. M. BARNICOT congratulated Mr. Beuttell and the Committee on the very able work done. He would like to raise one or two points of interest. In regard to floodlighted football it seemed that the figure of 13.5-foot candles would certainly be adequate, but it might be considered excessive when viewed from an economic standpoint. He was not clear whether the illumination referred to in the American installation was vertical or horizontal. It seemed probable that the figure mentioned was a maximum rather than a minimum. Usually the maximum intensity occurred in the centre of the ground and the minimum near the touch-line. This would depend, however, upon the design of the installation. In either case one might take it that football could be played under apparently good conditions here and on the Continent with considerably lower values of illumination, as had been revealed by investigations in which he had been interested. From an architectural point of view, floodlighting, he thought, was a question for the individual engineer. Floodlighting called for an artist as well as an illuminating engineer. It was not a question of working out foot-candles, but of providing a picture of light. In the light of what had been said by the author he did not see how the method could be applied to the new architectural installations, which were treated in individual sections to form one lighted whole.

He was also interested in the intensity given for the lighting of an operating table. There were two points that he could confirm. He was recently present during an operation carried out under an intensity of 700 foot-candles. One point which definitely struck him was that within the wound the reflection factor difference was uniformly low. The second point related to the surround. It was usual to surround the wound with white towels, which, by contrast, made the brightness within the wound appear low; if dark towels were used the visibility would be very much better.

Mr. F. C. RAPHAEL said one could not take in completely such a vast and magnificent piece of work in one night. It represented, he thought, one of the most outstanding steps in the theory of illumination in his time. They all realised, however, that the factors given were only tentative. He thought that the contrast figures might require a little fuller investigation and experiment. Possibly the contrast would eventually have to be divided into two separate characteristics. He had not yet plotted out the curves connecting the figures representing the various characteristics and the corresponding multipliers, so did not know whether they were intended to follow a straight line law, but the values at the two ends of the scale in each case might require some variation. Thus, in the operating theatre the selection of 30 or 40 instead of 20 for the contrast multiplier would make all the difference. Another point that certainly demanded investigation was the illumination of the surroundings, which might make a great difference to the result.

Mr. J. S. DOW said he wished to endorse all that had been said in regard to the value of the paper which was, in some respects, unique. At this late hour he would only attempt to raise a few points. A leading feature in Mr. Beuttell's scheme was the importance attached to difference in reflecting value. This led him to compare the tasks of sewing, first with black cotton

on black cloth, and second, with white cotton on white cloth. In both cases the difference in reflecting power would be the same, i.e., zero. Ought one to apply the same multiplying factor and hence to specify the same illumination? If so, this would be opposed to existing impressions, for it was commonly assumed that the theoretically requisite illumination for any task was inversely proportional to the reflecting factor—a conclusion which was, in fact, supported by certain experiments at the National Physical Laboratory. He would also like to ask whether the requisite illumination in these two cases would not necessarily depend on the nature of brightness of surroundings, for which provision did not yet appear to have been made in the table? This last question, he thought, also affected the visual task of watching a football match played by artificial light; in such cases the fact that the sky was black instead of white seemed to depress vision—though perhaps the inherent difference in diffusion by natural and artificial light was here the main factor.

In conclusion, Mr. Dow mentioned the suggestion that a further informal meeting should be arranged, at which the discussion could be continued, and any members who had further posers to put to Mr. Beuttell would have an opportunity of presenting them. He asked any of those present who would like to attend such a meeting to communicate with him.

Mr. A. CUNNINGTON welcomed the suggestion for an informal meeting at which Mr. Beuttell's valuable work could be further discussed, and he took the opportunity of putting forward confirmation of the method in resepct of advertisement hoarding. He had made measurements of Illumination on a large illuminated nameboard near Wimbledon Station which was virtually an advertisement hoarding viewed from a moving train and, therefore, according to the Factors given in Table 1 should have an illumination of 6.75 foot-candles. The actual illumination over the board was found to vary between six and seven foot-candles.

This remarkably close agreement made it look almost as though the system might have been worked backwards from actual results in practice, and he supposed that to some extent it was true that certain of the Factors were based arbitrarily on the resultant of good practice. This was by no means to belittle the valuable work done, in fact it seemed that in dealing with those Factors which could not be arrived at by any definite mathematical method it would be quite reasonable to base the system of good practice so that we could work as it were from the "known" to the "unknown."

Mr. T. L. MINCHIN (*Communicated*): It seems particularly necessary to apply this scheme to some visual task, which admits of simple analysis and has been quite extensively investigated. Such a task is afforded by the Luckiesh test cards which have again been used in some work on acuity of vision which Mr. K. Y. Tang* has recently conducted at Ohio University. Treating these cards on the basis of Mr. Beuttell's scheme we have

Size (0.3 mm. at 14 in.) 2.9 ft.	x 2
Contrast (light ground .15 blacklines not more than .05) 0.1 ft.	x 10
Illumination required ..... 20 foot-candles.	

Mr. Tang's curves, however, show practically no increase above 4-5 foot-candles. While this is a "threshold" figure, the discrepancy still seems worthy of some attention. Luckiesh, however, states that there was an improvement on increasing the illumination up to 20 foot-candles.

As some of the earlier speakers, I feel that mere unqualified foot candles are not an entirely satisfactory criterion of illumination. The German code includes, I believe, a quantity termed "schatigkit," which is measured by the ratio of intensity of illumination in shadow to the unshielded illumination. The value of this quantity should also be prescribed when assessing the illumination requirements for a given task.

There is another factor not referred to in the paper which appears to affect the amount of light required for a given task, i.e., the colour of the light. Published research work by the Illumination Research Board and Mr. Tang both indicate that there is considerable advantage resulting from the use of daylight, as compared with artificial illumination of the same intensity. Also the colour of light may have a specific effect on one class of work; for example, the visibility of red objects, under mercury vapour discharge tubes (the light of which is devoid of red) would undoubtedly be much lower than for equal illumination of more normal colour.

Mr. BEUTTELL, in reply, said he would like to acknowledge the generous remarks made by the various speakers in regard to his paper. So far as the members of the Committee were concerned he could assure the meeting that all the credit was not due to him on this subject, as he would have had the greatest difficulty in the world to prepare the paper without their help.

In reply to Dr. Walsh, he explained that if the reflection factor of the ground were ρ_1 the method provided that in the first place the ground should be illuminated to the standard brightness of the basic task, i.e., unity by multiplying by ρ_2. However, as this raised the brightness of the detail also, a further correction was required to give constant brightness difference by multiplying by the reciprocal of the contrast. If E_w be the working illumination; E_b the basic illumination, ρ_1 the reflection factor of the ground, and ρ_2 that of the detail.

$$E_w = E_b \times \frac{1}{\rho_1} \times \frac{\rho_1}{\rho_1 - \rho_2} = E_b \times \frac{1}{\rho_1 - \rho_2}$$ (ρ_2 being reflection factor of detail) $\therefore B_1 - B_2 = E_b$ = constant taken in the paper as unity.

If the multiplier were taken as $\frac{1}{\rho_1 - \rho_2}$ the two operations were thus combined in one, and it would be noted that the numerical factors in the table were, in fact, the reciprocals of the differences in reflection factor. Regarding type-setting, he had assumed that after a little use the cavities in the type became dirty and dull, whilst the face became bright. He had considered the contrast between the bright face of the type with a minimum of specular reflection in a diffuse lighting system and darker cavities and selected the R.F.D. arbitrarily.

Answering Mr. Wilson, the basic principle of the method was such that no illumination for any purpose could be admitted as adequate for proper vision which was less than the basic illumination. There could, therefore, be no such thing as a half foot-candle unless dictated by economy. He agreed that the system when applied to street lighting might give Class "B" values. It confirmed that for adequate visibility all should be in this class, and that it was only for reasons of economy that they were not. In reply to Mr. Masterman's queries, he personally would legislate for the number of the greyhound. In office work he suggested choosing the most difficult task which enters consistently and seriously into the work which has to be done and relying on extra physiological effort for the infrequent and more difficult tasks. In the printed paper it was suggested as a general principle that when the predominant feature of a task requires a given illumination, and the most exacting operation can be performed under that illumination with a momentary extra effort, the basis of calculation should be the former and not the latter. This would apply to mixed tasks.

He agreed with Mr. Jones that until the system is perfected existing codes must be employed.

Replying to Mr. Long, who enquired what would be

* Trans. Amer. Ill. Eng. Soc., April, 1933.

the ultimate form of the presentation of this Code, it would give the usual list of tasks which would have been worked out and checked by the method. It would be in booklet form, and would contain sufficient information to assist people in their choice of multipliers. It would also contain all the little tips they had learned themselves, and would clearly explain how they should be applied. It would not be necessary to work out each case unless it were so desired. Luminous objects had not been considered. Glare would be dealt with at a later date. Regarding defective vision, he felt that it was only possible to legislate for the normal eye.

Replying to Mr. Peirce, it should be possible to show consumers, if it were so desired, that a logical basis had been employed in figures recommended. Regarding floodlighting installations, he believed that shadows must be considered if it is to be effective. In answering Mr. Stroud, Mr. Beuttell said that factors had been selected so as to give results conforming with good current practice, because this was the object of the method. Such values were, however, often inconsistent with absolute equality of performance, with which it seemed that practice had unconsciously compromised.

Replying to Mr. Barnicot's queries, he presumed the figures for the football ground at Huron College referred to vertical illumination. They were quoted for the centre of the pitch, but it was not stated whether they were a maximum or a minimum. The reflection factor difference in the surgical operation in the example was 0.05.

He explained to Mr. Raphael that there was at present no methematical basis for obtaining the moving vision factors.

Mr. Dow was quite correct in his assumption that in choosing the factors the results would be the same for both light and dark-coloured fabrics if the reflection factor only were taken into account, but in working with the light material the contrast would be provided by shading on or shadows cast by warp and weft of the fabric (and the sewing cotton); thus with the light material there is a considerable difference in the shadows, but this is not the case with the black, therefore the black needs a greater illumination. In the case of black material, advantage would be taken of any specular reflection on the tops of the threads. In examining black material, he believed that one naturally held dark fabric in the best position to obtain maximum specular reflection from the threads. The method of working backwards from practice to results, as suggested by Mr. Cunnington, was exactly what had been done in the first place in co-ordinating the results with practice, but the later work had already included some treatment on a more scientific basis without departing from the agreement with practice.

Before closing, he would like to acknowledge the kindness of the E.L.M.A. Lighting Service Bureau in preparing the exhibits, and to thank those present for their kind reception of the paper.

Literature on Lighting*

(Abstracts of recent articles on Illumination and Photometry in the Technical Press)

II.—PHOTOMETRY.

1. Aids to the Photometry of Searchlights. F. Born and H. Knauer.

Das Licht, *pp.* 245-247, *December* 15*th*.

The contribution deals (a) with the measurement of candle-power with the aid of an integral sphere; (b) with a method of test enabling departures of the mirror from the parabolic form to be readily detected.

J. S. D.

III.—SOURCES OF LIGHT.

2. Three Different Wattages from One Lamp. Anon.

El. World, 102, *p.* 672, *November* 18*th*, 1933.

New twin filament lamps which can be made to consume three different wattages are described. These lamps are at present made in two ranges—namely, 150-350 and 200-500 watts.

W. C. M. W.

3. Combining Mercury, Vapour, and Incandescent. Lamps to Produce Commercial White Light. D. R. Grandy.

Am. Illum. Eng. Soc. Trans., 28, *pp.* 762-773, *November*, 1933.

Discusses the value of a white light which, although not perfectly spectrally, can be produced efficiently. With the mercury pool lamp, experiment has shown that, roughly, two watts of incandescent light to one of mercury is an average choice for the best effect. Installations are described.

G. H. W.

4. Incandescent Lamps as Mercury-Arc Ballast. E. J. Buttolph.

Gen. El. Rev., 36, *pp.* 482-485.

It is a characteristic of all arc lamps that about one-third of the applied voltage must be absorbed in series impedance. The article describes a method of ballasting an a.c. arc with filament lamps so that increased efficiency and power factor are secured. In the case of the mercury arc described, it is stated that at the same time a desirable colour mixture is obtained.

G. H. W.

5. Improved Gas-filled Lamps. Anon.

El. Times, 84, *p.* 590, *November* 2*nd*, 1933.

A new method of suspending the filament of the gas-filled lamp is said to permit burning at any angle without shortening life. Diagrams are given.

W. R. S.

6. Developments in Gas Discharge Lamps. Anon.

El. Times, 84, *p.* 741, *December* 7*th*, 1933.

An account of the development of hot cathode discharge lamps, with special reference to the " Sieray " lamp. Points discussed include:—Control of colour, electrical characteristics, applications and production of white light by mixing with tungsten filament lamps. Several diagrams and photographs are presented.

W. R. S.

7. Dimming of Hot-cathode Gaseous Discharge Lamps. W. F. Westendorp.

Gen. El. Rev., 36 *pp.*, 488-492.

Details are given of a starting arrangement for d.c. and a.c. lamps. The latter can be arranged in a cir-

* Abstracts are classified under the following headings: I, Radiation and General Physics; II, Photometry; III, Sources of Light; IV, Lighting Equipment; V, Applications of Light; VI, Miscellaneous. The following, whose initials appear under the items for which they were responsible, have already assisted in the compilation of abstracts: Miss E. S. Barclay-Smith, Mr. W. Barnett, Mr. S. S. Beggs, Mr. F. J. C. Brookes, Mr. H. Buckley, Mr. L. J. Collier, Mr. H. M. Cotterill, Mr. J. S. Dow, Mr. J. Eck, Dr. S. English, Dr. T. H. Harrison, Mr. C. A. Morton, Mr. G. S. Robinson, Mr. W. R. Stevens, Mr. J. M. Waldram, Mr. W. C. M. Whittle, and Mr. G. H. Wilson. Abstracts cover the month preceding the date of publication. When desired by readers we will gladly endeavour to obtain copies of journals containing any articles abstracted and will supply them at cost.—Ed.

cuit arranged for dimming the lamps by arranging for the discharge to pass for only a part of the cycle. The practical installation at the Chicago Exposition is described in detail. G. H. W.

IV.—LIGHTING EQUIPMENT.

8. Illumination Characteristics of Organic Plastics. A. Paulus and C. S. Woodside.

Am. Illum. Eng. Soc., Trans., 28 *pp.*, 749-750. *November*, 1933.

After describing the characteristic physical properties of a number of modern plastics (e.g., Celluloid, Bakelite, and Beetleware), their diffusion, transmission, reflection, and heat resisting properties are given. G. H. W.

9. Types of Neon Sign Flashers. H. S. Coleman.

Signs, *p.* 111. *December*, 1933.

A brief description of the chief forms of flashers for use with neon lamp signs and tubes, including rotary wiping brushes, mercury tubes, H.T. arc gaps, and thermo-flashers, and chokes. J. S. D.

10. Lighting for Artificial Skylight. R. A. Palmer.

Elec. World, 102 *pp.*, 701, *November 25th*, 1933.

A novel method of artificial skylight lighting is described. Each glass panel is completely enclosed on the upper surface by an aluminium box having an oxidised inner surface, and thus giving a greater efficiency than with the more usual methods of laylighting. Each of the 64 units consumes 200 watts. W. C. M. W.

V.—APPLICATIONS OF LIGHT.

11. The Year's Progress in Illumination. W. C. Brown.

Am. Illum. Eng. Soc., Trans., 22 *pp.*, 733-748, *November*, 1933.

The year's progress in illumination is classified under various headings. No useful abstract can be given. G. H. W.

12. Light and Architecture. Anon.

Am. Illum. Eng. Soc., Trans., 28 *pp.*, 719-728. *November*, 1933.

Illustrated descriptions of eight modern lighting installations in the U.S.A. G. H. W.

13. Cumberland Hotel. Anon.

Elect., 111 *pp.*, 749-751, *December 15th*, 1933.

A detailed description is given of the lighting equipment at the new Cumberland Hotel. Architectural lighting is used extensively, and many novel features are employed. Photographs are given. C. A. M.

14. Highway Lighting in Italy. Anon.

Elect., *p.* 764, *December 15th*, 1933.

An interesting example of roadway lighting for motor transport in Italy is shown in a set of three photographs dealing with the road between Rome and Ostia. C. A. M.

15. Gaseous Discharge Lighting. Anon.

Elect., 111, *p.* 713-714, *December 8th*, 1933.

Details are given of new street lighting installations using gaseous discharge lamps at Ilford and Kingston-on-Thames. In both cases directional lanterns are used. Photographs are given, and also an iso-candle diagram for a portion of the installation at Ilford. C. A. M.

16. The Decorative Lighting of Gardens. V. H. Very.

La Revue de l'Eclairage, *pp.* 121-2, *November*, 1933.

A brief illustrated description of various luminous devices for use in gardens. The article is concluded by a summary of the consumption necessary for general illumination and for special lighting effects. J. S. D.

VI.—MISCELLANEOUS.

17. The 1931 International Commission on Illumination (I.C.I.) Standard Observer and Co-ordinate System for Colorimetry. D. B. Judd. (Bureau of Standards). Washington.

Journ. Opt. Soc. Am. 23, *pp.* 359-374, *October*, 1933.

This report makes available the properties of the standard observer recently recommended for colorimetry by the International Commission on Illumination. The data here given supersedes the values published in the 1922 report of the committee on colorimetry. Forms are given for computing trilinear co-ordinates (trichromatic coefficients) dominant wavelength, colorimetric purity, and luminous transmission (or reflectance) from spectrophotometric data. Tables of the data needed for the 1931 I.C.I. standard illuminants, A, B and C are included. T. H. H.

18. Some Complementary Colour Relations. E. Genberg.

Proc. Phys. Soc. 45, *pp.* 836-840, *November*, 1933.

The author has determined pairs of wave-lengths which are complementary with respect to equi-energy radiation taken as white. The energy and luminosity of one of the complementaries for unit luminosity of the white are given. T. H. H.

19. Conduction of the Second Type in Certain Gas-filled Photo-electric Cells. L. Dunoyer and P. Paonnoff.

Rev. d'Optique 12, *Nos.* 6-7, *pp.* 241-264, *June-July*, 1933.

The characteristics of a gas-filled photo-electric cell with a hemispherical cathode, plane window and wire anode are investigated. In addition to the classical or normal type of conduction a second or high-voltage type, which the authors term the second regime of action, is observed immediately before disruptive discharge occurs. If a sufficiently high voltage is applied suddenly after the cell has been suitably prepared, the conduction is first of the normal type, and then of the second type, before disruptive discharge occurs, each type lasting for a few hundredths of a second. If the variations in the light falling on the cell are sufficiently rapid the current in the second type of conduction is almost proportional to the incident light flux. It is concluded that conduction of the second type is due to the emission of secondary electrons from the cathode under the influence of positive ion bombardment, the magnitude of the latter depending on the field strength and the geometrical characteristics of the cell. L. J. C.

20. Light Penetration in the Waters of the San Juan Archipelago. C. L. Utterback and J. Watson Boyle.

Journ. Opt. Soc. Am. 23, *pp.* 333-338, *October*, 1933.

By means of a photronic cell and red, green, and blue filters, the values of the absorption coefficient of the water at several stations in the San Juan Archipelago were found.

The absorption coefficient y is defined by the equation $I=I_0e^{-yd}$ where I_0 is the intensity of the light just beneath the surface, d is the depth in metres, and I is the intensity of the light at a depth of d metres.

A typical set of values of y is given in the Table:—

Depth.	y		
(inches).	Blue light.	Green.	Red.
0 } 5 }	·232	·187	·456
10	·215	·190	·396
15	·187	·171	·336
20	·213	·168	·362
25	·233	·202	·262
30	·216	·211	·209

T. H. H.

Recent Patents

Spec.: No. 392,077, Illuminating-Devices for Microscopes: Discharge Lamps.

An illuminating device for a microscope comprises a luminous electric discharge tube arranged around the optical axis of the microscope partially or entirely and placed substantially at the level of the object. For use in photomicrography a tube having a filling of mercury giving an emission rich in blue and ultra-violet rays may be used.

Spec.: No. 390,488, Colour Filters.

A filter for absorbing red light intended partially for signalling purposes, consists of a yellow glass layer, combined with one or more layers of green, blue, or white glass. The supplementary layers serving for absorbing the excessive red rays transmitted by the yellow glass. The several layers may be welded together or merely placed one above the other.

Spec.: No. 384,362, Photometry.

Photo-electric cells which generate an E.M.F. under light action are used for light measurement, controlling ultra-violet and other purposes under conditions such that the current in the cell circuit cannot rise above the current at which fatigue can occur. This current limination may be attained by an adjustable resistance in the cell circuit, or by means of a counter E.M.F. The subject of this patent is the method using a counter E.M.F. The instrument may also be fitted with interchangeable filters for modifying the action on the cell.

Spec.: No. 381,696, Photometric Apparatus.

The optical density of a liquid is measured or compared with that of a standard liquid by transmitting light through a variable aperture and through the liquid on to a light sensitive cell. The deflection of an electrical indicating instrument connected to a cell being brought to a predetermined value when a solution of known optical density is in the path of the aperture, or by adjusting the temperature of the lamp filament constituting the light source.

Spec.: No. 397,774, Discharge Lamps.

To prevent excessive strains in a luminous tube, two or more parts of the glass tubing are joined together with gas-tight joints. These joints are made with flexible metal tubes, which may be of spring steel, or bronze, and preferably, are partially or wholly corrugated.

Spec.: No. 402,019, Improvements in or Relating to Lighting and Ventilating Systems for Vehicles.

This invention relates to vehicle devices and particularly illuminating and ventilating for long car bodies, such as buses, tram-cars, and railway carriages. The primary object is to provide a soft, evenly distributed, or diffused light, which shall not be harmful to the eyes, yet giving sufficient illumination for all ordinary purposes.

Spec.: No. 401,988, Electric Discharge Tubes.

This invention relates to discharge tubes, and is of great importance for X-ray tubes. It consists of a rotary anode, and relates to the type of discharge tubes having a movable anode, more particularly to a rotatory anode, in which the dissipation of heat to the outside is greatly improved. The essential feature is the provision of a metal body by which the heat radiated by the movable anode, can be absorbed and carried off to the outside.

Spec.: No. 401,903, Arrangements for the Feeding of Current to Gaseous Discharge Luminous Tubes.

The invention sets forth two methods of employing transformers for Neon Tubes. One method is to use a single transformer of normal type, to which all the tubes are connected in a single series, or in a number of parallel series. The other method is to use a plurality transformer of the type having a magnetic shunt, in which case there is connected a series of tubes or a single tube to each transformer.

Spec.: No. 401,846, Electric Discharge Lamps.

This invention relates to methods of modifying the light from electric discharge lamps by means of phosphorescent substances, or fluorescent substances.

Spec.: No. 401,838, Improvements in Lighting Fittings.

This invention relates to a novel fitting, which is so arranged as to provide a comparatively long and narrow zone of illumination. The longer sides of the zone having fairly sharply defined boundaries. Fittings of this type are suitable, for example, for the illumination of racetracks, such as are used for dog-racing, where it is undesirable for light to fall on the eyes of observers.

D. K.

Illuminating Engineering Society Forthcoming Meeting in Manchester

We learn with pleasure that a special meeting has now been arranged to take place at the Engineers' Club, Manchester, on Tuesday, January 30, when a paper on Electric Discharge Lamps will be read by Mr. H. R. Ruff. It will be recalled that Mr. Ruff, who is associated with the Research Department of the British Thomson Houston Co., Ltd., at Rugby, was responsible for an interesting demonstration at the opening meeting of the Society in London on October 10.

This announcement of this meeting, following after the recent gathering in Liverpool (described on p. 4 in this issue), illustrates the enterprise of the local section for the North-Western Area, which will doubtless add considerably to its membership during the present session. We strongly advise all engineers, contractors, and others interested in lighting to become associated with this local section, and to communicate with the local honorary secretary (Mr. James Sellars, Highways Dept., Town Hall, Manchester).

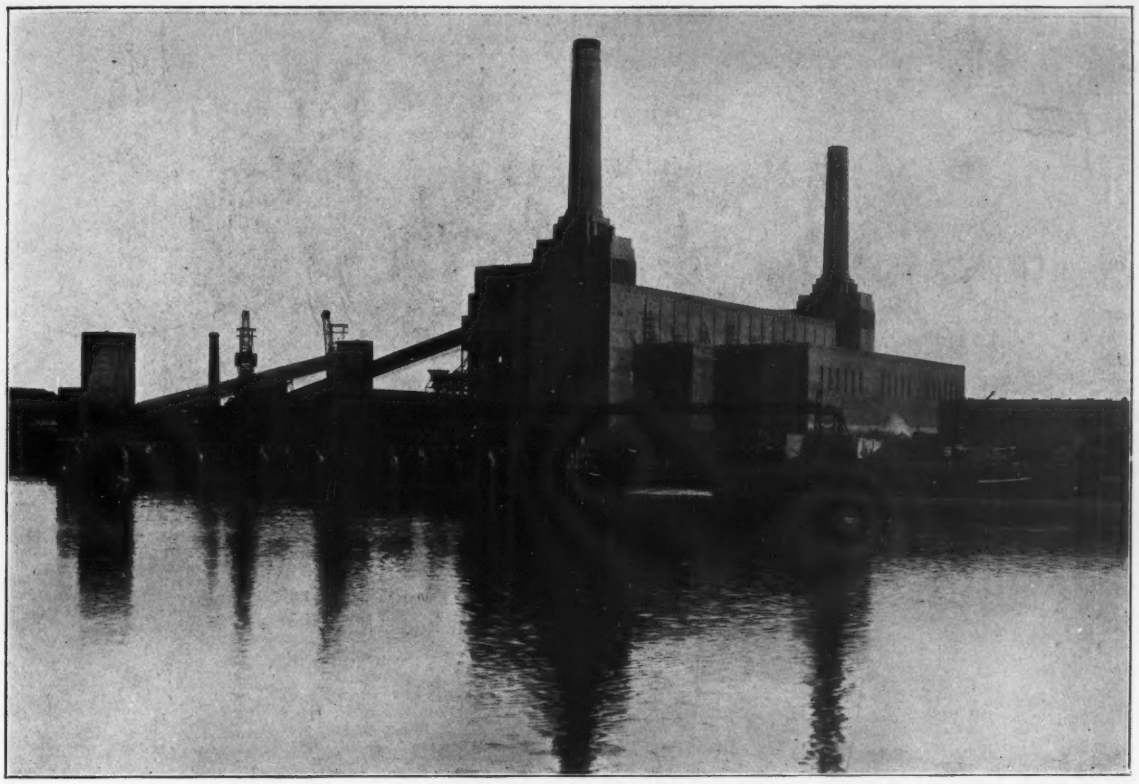


Fig. 1. A General View of the Power Station from the North Side of the River.

The New Battersea Power Station

The Lighting Presents Many Problems of Interest to Illuminating Engineers

IN what follows we give a brief description, in which special attention is given to the lighting arrangements of the new Battersea Power Station, which members of the Illuminating Engineering Society had the privilege of visiting on November 28th.

This station occupies a site of about 15 acres on the south bank of the Thames and forms an important link in the transmission scheme for south-east England. The station as at present being represents approximately half of the full projected plan. It is understood that the ultimate capacity of the station will be in the neighbourhood of 450,000 kw. At present two turbines of 69,000 kw. capacity have been installed and are in operation, and an additional unit of 105,000 kw. capacity is on order. The building when completed will be approximately square (500 ft.) with the boiler house at the centre. Each of the six boilers at present installed is rated for a maximum peak evaporation of 330,000 lb. of steam per hour at 650 lbs. per sq. in. and 875-900° F. The normal evaporation is rated at 250,000 lbs. hr. per unit. Generation is effected at 11,000 volts 50 cycle, the machines operating at 1,500 r.p.m.

This new station forms a link with the other five generating stations of the London Power Company connected by means of 22 and 66 kv. feeders. The combination has the largest output of any electrical supply undertaking in this country.

Our first illustration shows a general view of the station with the two prominent chimneys, 337 ft. high and of reinforced concrete, which form a familiar sight to travellers from Victoria Railway Station. Incidentally, these furnish an interesting instance of effects of light, for the density of smoke is recorded and checked by the aid of a photo-electric cell illuminated by a ray of light which traverses the flue of each boiler. The presence of dark smoke at once causes diminution in the light reaching the cell and its warning message is transmitted to the boiler control desk.

Within the station one's chief impressions are of vastness of plant and of the smooth and silent running of the machinery. One was given to understand that the total staff does not exceed 150, and that at night time there are frequently less than fifty on the premises —a remarkably small number for such a huge enterprise.

THE LIGHTING OF THE STATION.

The lighting of this vast station presents many interesting features. One unique feature, which applies to the entire installation, is that in treating each separate lighting problem the lighting circuits have been divided up between A.C. and D.C. supplies, the latter supplemented by a service battery, so that a complete lighting failure is impossible. Holophane fittings have been specified and installed for all major

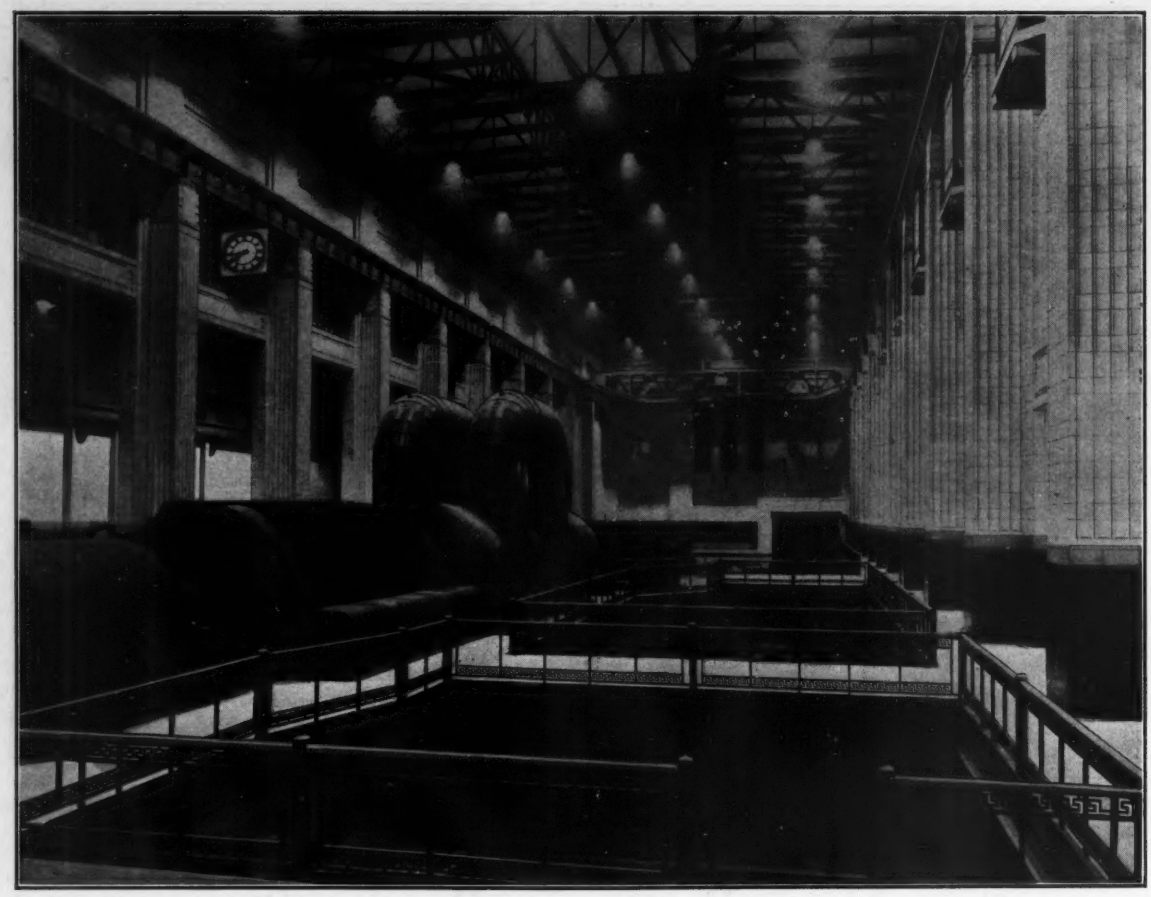


Fig. 2. A Night View of the vast Turbine House, lighted by 1,000-watt lamps in "heavy duty" units

positions. The Electrical Contractors were Messrs. G. E. Taylor and Co., of London, and the lighting was carried out in accordance with a carefully planned scheme prepared by the engineers of the London Power Company.

The Turbine Hall.

The Turbine Hall (Fig. 2) is approximately 470 ft. long and 80 ft. wide, with a height from the main turbine floor level of 68 feet. A cathedral-like effect is produced by the sixteen huge fluted pillars on either side. The main wall-surface has a pale blue mottled effect, with occasional use of darker blue to give relief. Exposed steelwork and the concrete ceiling are coloured to harmonise with this scheme. The artificial lighting of this large area is furnished by three rows of overhead Holophane concentrating type industrial units equipped with 1,000 watt gas-filled lamps. Seventy-five such units are used in the turbine room and in the adjacent mechanical annexe. The illumination on the turbine floor level is 8 to 10 ft.-candles—certainly a fully adequate value for a building of this character, and considerably higher than has sometimes been furnished in central stations in the past.

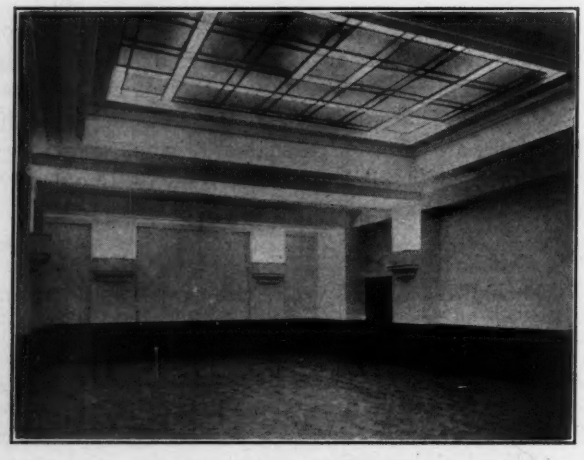


Fig. 3. The Assembly Room: Night View, showing combination of laylight and wall brackets.

Fig. 4. The Entrance Hall, for which a special Ceiling Unit has been designed.

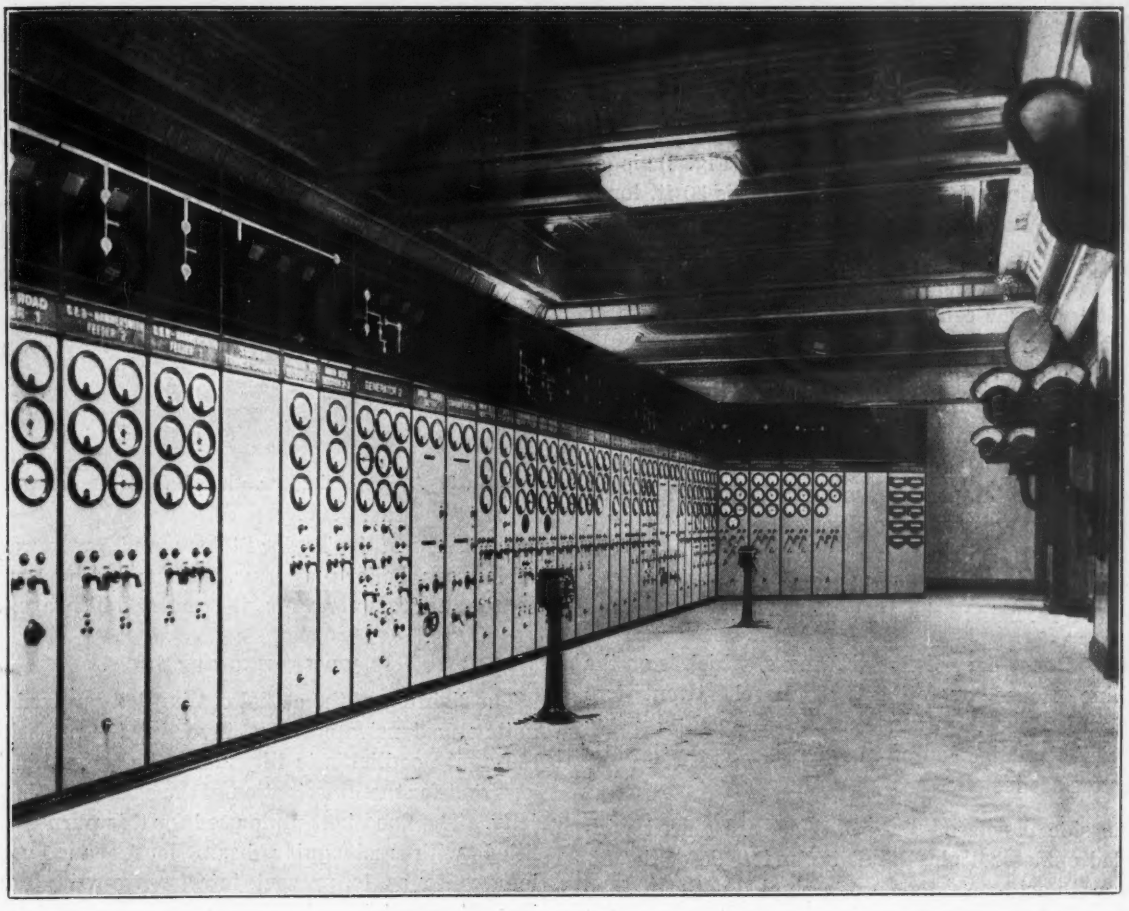


Fig 5. Night View of the Control Room, showing Ceiling-lighting supplemented by illumination of Indicator Board.

The Control Room.

The Control Room (Fig. 5) is on the west side of the Turbine House and overlooks it by means of six large bay windows. A feature of this room is the freedom from noise. The interior is lined with marble, the main wall surface being executed in beige colour, with a skirting in Belgian black. The ceiling admits both daylight and, from the beams, artificial light, the latter being furnished by special Holophane Hedralite ceiling fittings; these are supplemented by prismatic plates recessed in the return panels of the laylights in order to build up the vertical illumination of the control panels. These plates have been fitted with special louvre attachments to avoid troublesome reflections being formed amidst the circuit diagrams, which are themselves depicted by easily visible luminous lines.

The Entrance Hall (Fig. 4) is likewise finished in beige and black marble. The lighting fittings here, executed to the designs of the architects, comprise special shallow close ceiling fittings for the centre ceiling panel and lift ante, with wall-brackets attached to the piers and walls. Pendant fittings of

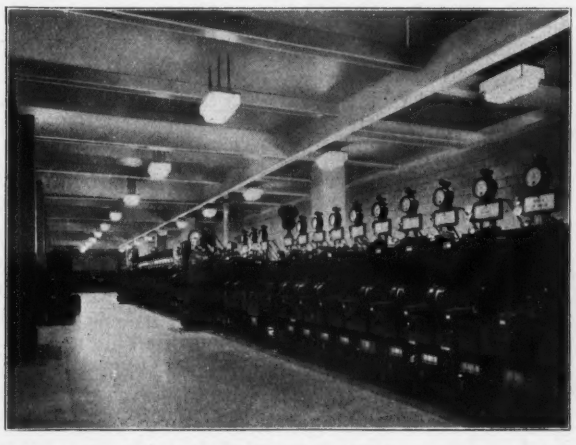


Fig. 6. House Service Board Annexe. Night Photograph, showing novel Ceiling Units.

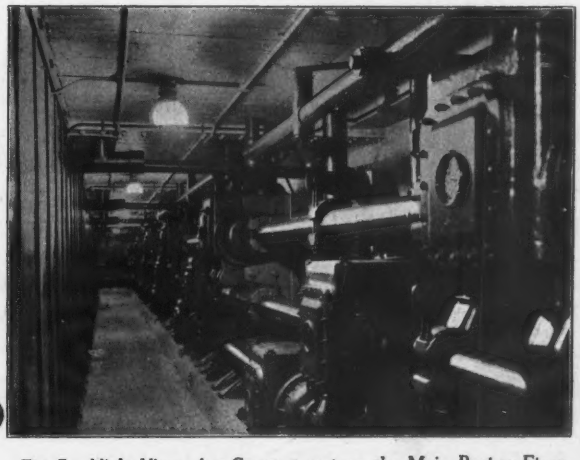


Fig. 7. Night View of a Compartment on the Main Busbar Floor, lighted by 150-watt Gasfilled Lamps in assymetrical dome refractors.

similar design are used for the landings on the main staircase adjoining.

The Assembly Room.

The lighting of the Assembly Room (Fig. 3) is of a highly original character. The room is 50 ft. long, 30 ft. broad, and 14 ft. 6 in. high. Natural lighting is derived entirely from a central laylight approximately 14 ft. by 19 ft. The substantial beams carrying the remainder of the ceiling would render any system of lighting by pendants or ceiling panels very difficult. A combination of indirect brackets and decorative laylight panels was therefore adopted. For the former special fibrous plaster forms were designed for attachment to the eight projecting piers, and were used to house 150 watt lamps in assymmetric reflectors. Four such reflector units were used for each position. Holophane Hedralite plates have been combined with the design of the central laylight, types 6 in. square and 6 in. by 9 in. being used alternately.

In the House Service Board Annexe, which is on the Turbine House operating floor level, twenty-two rectangular two-tier fittings, each equipped with two 300 watt gas-filled lamps in extensive type prismatic reflectors are installed.

The side panels of these fittings are glazed with rippled opalescent glass and the underside of the fittings with acid etched glass of a rippled pattern. The positions of these units have been specially selected with a view to the avoidance of surface-reflections.

Miscellaneous Problems.

Amongst other lighting problems we may mention the 60,000 volt Switch House, the Boiler House, and the Coaling Jetty.

The Circuit Breaker Chamber is divided by collapsible shutters into three separate compartments, each section being lighted by means of ten 1,000 watt gas-filled lamps in extensive heavy duty units. The treatment of the Busbar floors needed special study, in view of the importance of achieving good vertical lighting from floor level to ceiling. This condition was effectively met by the use of 150 watt lamps in dome refractors.

The Boiler House, which is over 150 ft. in height, has a total length of 480 ft. The general lighting of the Firing Aisle is effected by 500 watt lamps in extensive units. In the Control Aisle there are fifty-four concentrating units equipped with 500 watt lamps mounted at 68 ft. o/d, supplemented by 300 watt units of a similar type at 104 ft. o/d. Supplementary to the above a considerable number of B.E.S.A. dispersive industrial reflector units and elliptical angle vitreous enamelled reflectors have been furnished by Benjamin Electric, Ltd.

Some hundreds of Holophane bulkhead units and enclosed industrial units are used for various subsidiary purposes, such as for lighting the operating

Fig. 8. A View of the Jetty, which is floodlighted at night.

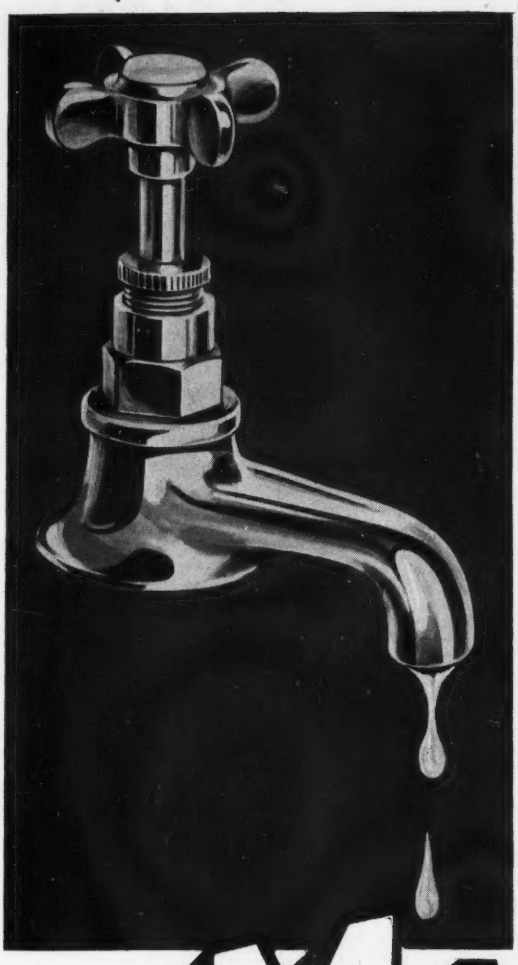
mechanisms of the Taylor Stokers and for the various cable ways, boiler platforms, the rear areas of switchboards, the coal elevators, the gantry walkways, etc.

Floodlighting the Jetty.

The lighting of the actual coaling jetty proved to be quite an extensive business, involving the provision of 500 watt floodlights to illuminate the steamship bunkers and for the illumination of the entire length of the jetty. The floodlight units used for this purpose were fitted with rectangular beam lenses and vertical louvres so as to prevent interference with navigation. These latter floodlights are accommodated on the crane supporting structures and also upon the first coal elevator tower. Safety lighting along the jetty has also been carried out by means of bulkhead units attached to the sides of the coal conveyers.

The Illuminating Engineering Society in Australia

We have been favoured with a copy of the Annual Report of the Council of the above body for the year ended September 30. In several respects the practice of the Society, which seems to be making good progress, resembles that of the Illuminating Engineering Society in this country. The Australian Society has now fifty-three full members and thirty-seven associates. We notice with interest that eight firms have already become sustaining members. Another announcement of interest is the formation during the year of a Students Section which will admit to membership, at a nominal fee, students of a University or recognised Technical School. There are five Standing Committees, concerned respectively with Agenda and Programme, Constitution, Finance, Membership and Publicity. During the past year papers on Series Street Lighting, Train Lighting, the Illumination of Printing Works in Sydney, Architectural Lighting, The Eye, Luminous Gas Tube Manufacture, and Home Lighting Standards, have been read. In addition, several visits to places of interest were arranged. The question of the Society seeking legal status as an incorporated body is now under consideration.



You can see a leaky tap waste water, but you can't see a "cheap" lamp waste current.

USE **MAZDA LAMPS**

and get all the light for which you pay.

B T-H

Made in England by The British Thomson-Houston Co., Ltd.

PIONEERS OF GOOD LIGHTING

3492 A.

A Non-Reflecting Window for Shops, Showrooms, etc.

THE essence of an effective sales display is that it should create a definite desire to purchase on the part of the man in the street.

So very often one comes across cases where the most elaborate display and the most costly window-dressing have been nullified—indeed, in some cases rendered actually unattractive—by the barrier of plate glass interposed between the buyer and the seller. An atmosphere of aloofness—a definite sales resistance—can be engendered in this manner.

Possibly the greatest fault which can be found in flat plate-glass windows is that by their very nature they reflect the light which falls upon them from outside. Everyone is familiar with the fact that the angle at which a ray of light strikes a reflecting surface is equal to the angle at which it is reflected, and a moment's thought will show clearly that this unalterable scientific law must be held responsible for a great deal of the unsightliness and unattractiveness of the great majority of shop and showroom windows.

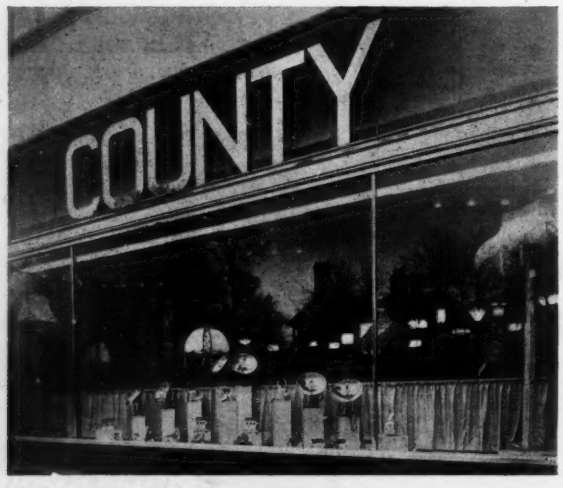


Fig. 1. A view of the flat windows formerly adopted for the showrooms of the County of London Electric Supply Company. The window display is marred by many reflections of objects in the street.

A glance at Fig. 1 will illustrate this point to advantage.

Supposing, however, that our window consists not of plain sheet glass, but of a concave sheet, then our law of angles of incidence and reflection still holds good; but if the glass is scientifically constructed, the reflected rays from *all sources* may be so redirected as to fall upon a predetermined spot, and this is the process followed out by the method under consideration.

The Reflectionless Window, which is a British invention, consists of a concave sheet of glass so designed that all reflected light from its surface falls on to two dead-black baffle boards arranged one at the top and one at the bottom of the glass.

The eye of the observer, therefore, looking at the glass from in front, is completely undisturbed, and is, indeed, quite unconscious of any reflection whatever on the surface of the glass.

The striking transformation which a normal window undergoes when replaced with the Reflectionless Window is clearly shown in Fig. 2.

The advantages of such a subject are manifold. Let us consider them briefly.

Firstly, of course, comes the greatly increased sales value of the window space, made possible by the enhancing in appearance of displayed goods.

The prospective buyer, viewing the goods clearly and without distraction, is able to form a better estimate of their value; indeed, so complete is the absence of all reflected light that the window itself appears to be non-existent, and the hand is instinctively put forward to take hold of the article.

From a financial point of view, the Reflectionless Window is claimed to effect a considerable saving in expense on artificial lighting, since every lamp in use is able to give its full illuminating value owing to the fact that the artificial lighting is not competing with the light from outside the window. It is, furthermore, claimed that considerably more daylight is reflected into the window by means of the device, and so on to the displayed goods themselves, a further important

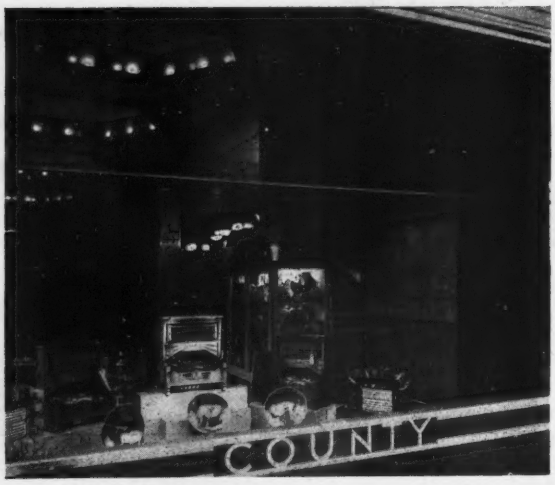


Fig. 2. The same window now fitted with non-reflecting concave glass. Unsightly reflections have completely disappeared.

Invisible Glass

No longer do buildings opposite and the constant stream of traffic cause annoyance or distract the interest of shoppers. All reflections are eliminated, detail is sharpened; colour tones are corrected by this wonderful new British invention that can be fitted to new or adapted to existing shopfronts.

★ ***With the Non-reflecting device no lighting is necessary during the hours of daylight to combat the reflections that fall upon the surface of ordinary glass.***

Another interesting point is the concession made to proprietors of showrooms fitted with a Non-reflecting window which enables them to illuminate the entire shop with a time switch during normal closing hours at a special rate, instead of the special rate applying only to enclosed windows.

With the Non-reflecting device you wonder if there is a window, for it is not at all apparent that there is a protective substance between the shopper and the showroom.

All interested should write for illustrated booklets, or see the demonstration model at Pollard's Showrooms, 299, Oxford Street, London, W.

Breves Lalique Galleries, New Bond Street.
Architects: Messrs. E. H. Stone and Partners.
Possibly the most charming Art Glassware Showroom in London, made doubly fascinating by the invisible window through which it is viewed

Westminster Electric Supply Corporation Ltd., Victoria Street.
Architects: Messrs. Adams, Thompson and Fry.
A similar window has been installed at the County of London Electric Supply Co.'s Showrooms at Streatham, and also numerous other showrooms.
Architect: G. Grey Wornum, F.R.I.B.A.

POLLARDS

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NON-REFLECTING DEVICE

Patent Nos. 354984 : 366393 : 617.

E. POLLARD & CO., LTD., 159, ST. JOHN STREET, CLERKENWELL, E.C.1.

Fig. 3. A view of the windows of the Westminster Electric Supply Corporation in Victoria Street, where non-reflecting windows have quite recently been fitted.

point, since every available foot-candle is of the utmost value in increasing the attractiveness of the display.

The Reflectionless Window is applicable to all shops, whether new or old, and can be incorporated in existing buildings without entailing many alterations.

As regards maintenance, there are no mechanical parts to become faulty, and no fittings which might need replacement, so that, once installed, the non-reflecting window costs no more in maintenance, indeed, needs no more attention, than does an ordinary plate-glass window. The actual makers and sole concessionaires for the installation of the Reflectionless Window are E. Pollard and Co., Ltd., of London.

Tower Bridge — the gateway to London's

OF the many triumphs achieved by Gas in the present movement for Better Public Lighting, certainly not the least is the retention of the lighting of Tower Bridge, London, after very exhaustive investigation by the Bridge authorities.

The lighting of Tower Bridge is undertaken jointly by the Commercial Gas Company and the South Metropolitan Gas Company, and it is interesting to note that when the bridge was first opened in 1894 it was equipped with Sugg's Lamps; now—forty years afterwards—when the lighting has been brought up to 1933 standards, Sugg's Lamps are again employed.

The approach from the City, with the Tower of London on right.

ABOVE—a "close-up" of one of the lamps.

commerce - RE-lighted by GAS!

Tower Bridge, because of its bascules and accompanying towers and arches, presents an unusual problem in bridge lighting; the very fine results obtained have called forth admiration from all classes of drivers who use the bridge, and are a real credit to the companies responsible.

Further details in regard to the Tower Bridge lighting, or any other phase of Public Lighting, will be furnished with pleasure by—

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The new Tower Bridge lamps were made by

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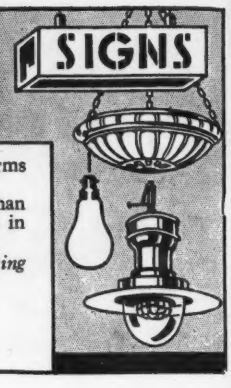

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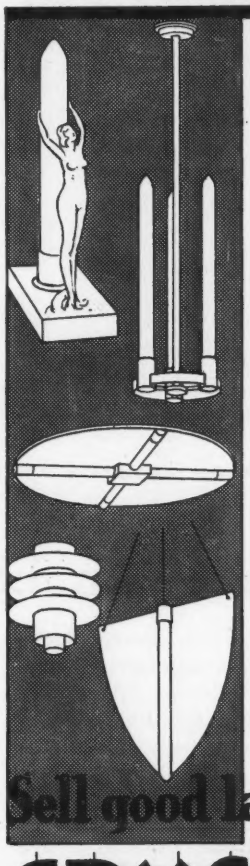

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MADE IN ENGLAND

Fig. 1. The Lighting of the new Trunk Road at Kingston-on-Thames by Osira lamps in special G.E.C. Fittings.

Street Lighting with Electric Discharge Lamps

EVER since the display at the Conference of the Association of Public Lighting Engineers at Margate last September the development of the electric discharge lamp has been watched with much curiosity. As is now well known there are several firms interested in the making of such lamps, which are expected to have special opportunities for the lighting of arterial roads.

This anticipation is already being fulfilled. We reproduce above a night-view of a section of the great trunk road running through Kingston-on-Thames, which was opened on December 1 by Mr. Frank Hodges. This is being lighted by the new " Osira " lamps developed by the General Electric Co., Ltd. The lamps, consuming 400 watts, are mounted 25 feet high in special fittings, are spaced on two sections, at 145 and 165 feet apart. Features of this new system are the soft light and good diffusion, the directional control of the system (whereby 6000 c.p. is emitted in the direction of traffic and only 3000 c.p. in the opposite direction), and the unusual colour of the light which, however, is not considered any great drawback on arterial roads.

This installation was carried out by the Borough of Kingston-on-Thames Electricity Dept., under the direction of Mr. T. A. Kingham, A.M.I.E.E., the Borough Electrical Engineer, and is the first of its kind in Surrey.

Another striking recent installation is that recently completed in Ilford, where Mazda Mercra lamps in B.T.H. lanterns are now in use. This is of special interest as being an ordinary suburban thoroughfare and not exclusively an arterial road. Nevertheless, apparently, the colour of the light has not operated as a drawback. It should be explained that the installation at Ilford falls into two sections, the first being an open space at Seven Kings Station (previously considered very difficult to light) and the second a stretch of the Romford Road where B.T.H. directional lanterns have been adopted (the " circular " type is used in the other section). The lanterns are mounted on alternate sides of the road 120 ft. apart and are mounted 20 ft. high. Foot-candle tests have shown very uniform illumination. (See Fig. 2a.)

Two other installations, for which Messrs. Siemens Electric Lamps and Supplies, Ltd., are responsible, may next be mentioned. One of these, the floodlighting of the Preston War Memorial with Siemens " Sieray " lamps, is an outdoor job (see Fig. 4). Two 400-watt lamps and two special concentrating floodlight fittings sufficed in this case. The " Sieray " lamp was also applied recently to the floodlighting of the façade of the Preston Municipal Building, which was effected with only 3200 watts, as compared with 8000 watts needed to produce a similar effect with filament gas-filled lamps.

Such lamps have obvious possibilities for the lighting of large outdoor areas. What is specially interesting, however, is to find them being used for indoor industrial lighting, as illustrated in the accompanying view of a large printing works (Fig. 3). The colour of the light is stated to be excellent for black and white printing, and it seems likely that these new lamps will find application in other industrial establishments.

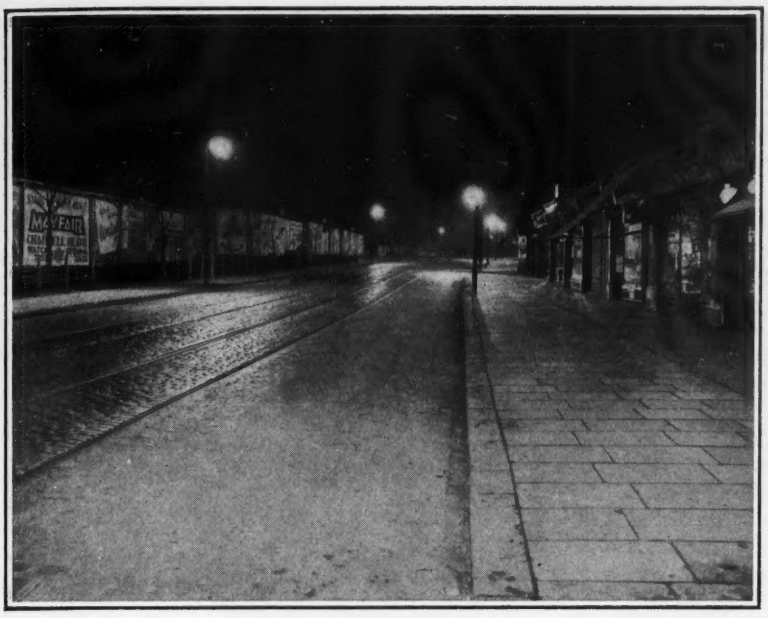

Fig. 2. Mazda Mercra Lamps at Ilford. A section of the Romford Road, showing B.T.H. Directional Lanterns fitted to tramway posts.

Fig. 4. The Preston War Memorial illuminated by "Sieray" Hot Cathode Lamps.

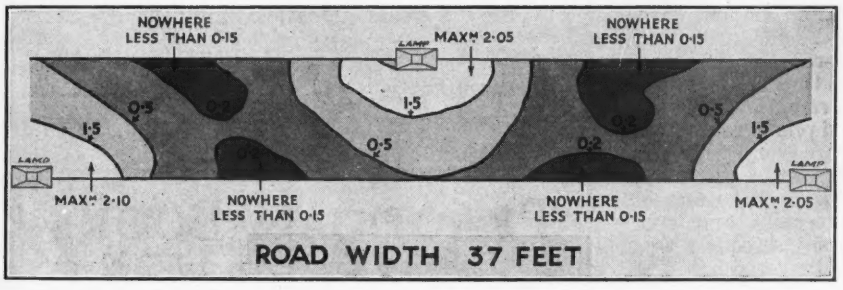

Fig. 2a. Iso-Foot-Candle Diagram showing Distribution of Light on one unit of the system at Ilford, comprising three posts, each equipped with a B.T.H. Directional Fitting. The distribution is considered very uniform considering the relatively low mounting height (20 feet).

All these developments will be watched with keen interest. No doubt public lighting engineers throughout the country will soon be experimenting with the new lamps. We hope that they will not fail to send us descriptions of these installations and notes on their experiences. Data in regard to the industrial use of these lamps will also be very welcome.

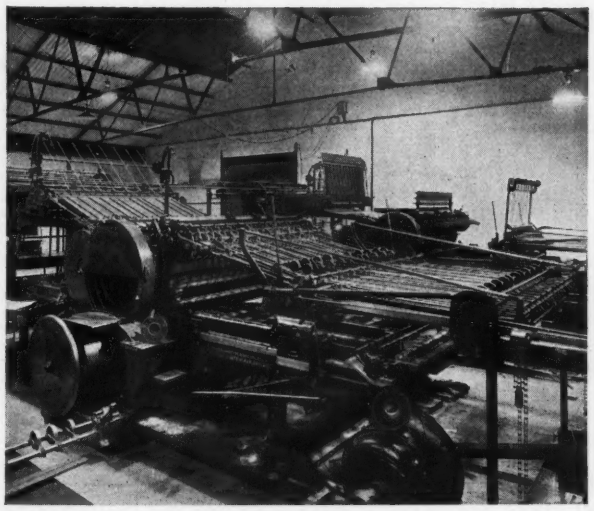

Fig. 3. A large printing works in which Siemens "Sieray" Hot Cathode Lamps have been installed.

Fig. 5. Another view of the Trunk Road, Kingston-on-Thames, illustrated in Fig. 1.

Lighting in the Cinema Industry

A VISIT to the Cine (Home and Industrial) Exhibition, held at the Dorland Hall, Regent Street, London, during November 27 to December 9, was instructive in showing the number of firms who are now prepared to help in the supply of equipment for the home and lecture theatre, as well as in industry. There were thirty-three firms on the list of exhibitors, which included suppliers of filming apparatus, projectors, lighting equipment, organs, etc. An interesting display, including a series of photographs of historic apparatus illustrating the evolution of the cinema projector, was staged by the Royal Photographic Society. Programmes of films were being shown in a series of miniature theatres. The catalogue of the exhibition contained an informative article by Miss Mary Field (Director of G.B. Instructional, Ltd.) on "The Present Position of the Film in Education"—the possibilities of which, even now, are hardly sufficiently grasped. It is, however, good news to learn that teachers and producers of films are now being brought more closely into touch with one another, and that a single standard projector (the 16 mm. type) is likely to meet the need of teachers without proving unduly expensive. An exhibit of special interest to readers of this journal was the model theatre studio equipped by Kandem Electrical, Ltd., on the first floor. Amongst the units demonstrated were 500/1,000 watt spotlights, 500 watt reflectors, and 4-reflector combination units, and a 2 kw. incandescent illuminator. The units selected for this exhibition were naturally of the type best suited to private studios and photography, but the scenery enabled one to compare very well the relative effects of arc and incandescent equipment, and the comparative effects of diffusion from masses of incandescent units and single reflectors and spot lights, with and without diffusing screens. One gathered that in modern technique the production of highlights and the use of concentrated beams is still considered essential. Purely diffused lighting, in fact, rarely forms more than 15-20 per cent of the lighting load of a modern scene.

One was also interested to hear something of the relative advantages of arc and filament sources in making talkie films, which formed the subject of an animated discussion before the Illuminating Engineering Society a few years ago. Experience has shown, as was then anticipated, that both forms of lighting are valuable in the modern studio, and that the troubles originally experienced in rendering the arc sufficiently noiseless may now be regarded as completely overcome. This achievement is the result of a number of contributory causes. Modern types of arc lamps and carbons for use with them burn more uniformly and noiselessly—the embodying of cores of improved uniformity in the carbons has been a help—and the design of chokers to smooth out any irregularities in the circuit is now much better understood.

The industrial depression has not been favourable to the introduction of radical departures in practice in the cinema world. It is understood, however, that the showing of films in approximately natural colours does not now present any very insuperable technical difficulty, and that the introduction of this novelty only waits upon a more favourable moment in the financial sense. The other great aim in cinematography —the giving of apparent solidity to pictures—seems less easy to realise. But there are certain stereoscopic methods which help considerably in giving depth to the picture and creating an impression of solidity and, no doubt, something more may be heard of them in the not far distant future.

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Catalogue of Lighting Accessories

Cinema Studio Lighting

The accompanying picture shows the variety of equipment at the service of operators in photographic and cinema studios, as illustrated at a recent exhibition in London. For this illustration we are indebted to the Kandem Electrical, Ltd. The multiple reflector "broadside" here seen in use is equally helpful in cinema work. It is assembled in a very convenient manner, capable of being used as an overhead unit or tilted at any angle. Amongst other devices illustrated in leaflets before us are the Kandem incandescent illuminator and spot, with a 400 mm. mirror suitable for use with 2,000 and 3,000 watt projection lamps, which is mounted in a tripod arrangement enabling the whole to be turned or raised and lowered with ease; and the portable Kandem Nitraphot reflector, used in the hand, and adapted to lamps of from 200 to 2,000 watts, according to size of reflector. These two items will serve to show how Kandem Electrical, Ltd., are equally prepared to meet large and small demands—as well as being equally at home with filament-lamp and arc-lamp equipment.

A Portrait Studio equipped with Kandem Lighting fittings for photographic work.

A View of the Stall of Messrs. Hailwood and Ackroyd, Ltd., at the recent Public Works, Roads and Transport Congress, where many examples of British made glassware, used in connection with luminous traffic devices, were shown, such as "Hailware" Three Ply Opal Glass Globes, Boulevard Globes, Beacon of Light Columns, and Hailwood's patented "Part Time" Flicker Lights.

Contracts Closed

EDISON SWAN ELECTRIC COMPANY, LTD.:—

Union Castle Mail Steamship Co., Ltd.: for the supply of Royal "Ediswan" Lamps during the six months commencing January 1, 1934.

SIEMENS ELECTRIC LAMPS AND SUPPLIES, LTD.:—

Union Castle Mail Steamship Co., Ltd.: for the supply of Siemens electric lamps during the ensuing six months.

Post Office Stores Dept.: for a large quantity of Siemens automobile lamps.

Credalux

Industrial, Commercial & Street Lighting Shopwindow

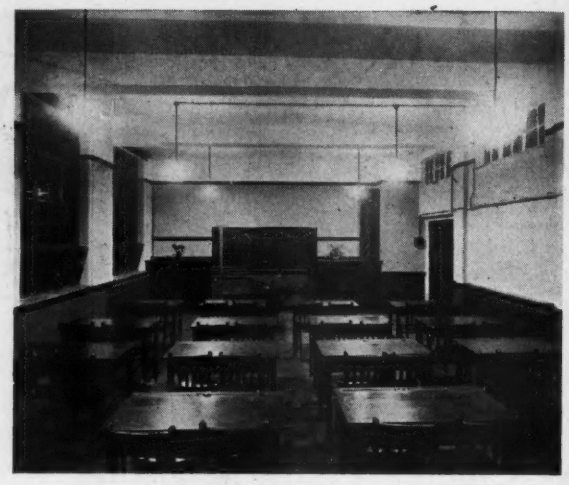
REFLECTOR FITTINGS

SCIENTIFICALLY DESIGNED

SIMPLEX ELECTRIC CO., LTD.

Head Office: 159, GREAT CHARLES STREET, BIRMINGHAM, 3

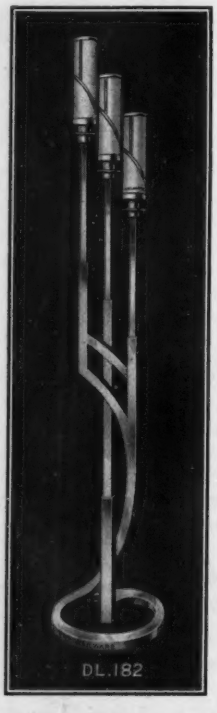
Assembly Hall



A Classroom

Lighting of Leyton Education Committee's New School at Connaught Road, Leytonstone

The above illustrations show the lighting of the assembly hall with Siemens' 16-in. diameter hexagonal ceiling fittings; each fitting is equipped with three 60-watt lamps and with rimpled glass panels, to ensure correct light diffusion. The classrooms are lighted with Benjamin "Benflux" fittings and Siemens' 100-watt gas-filled lamps.



This Chromium-Plated Standard Lamp of graceful design has been awarded the prize of £10.10.0 offered by Messrs. Hailwood and Ackroyd, Ltd., in connection with the Royal Society of Arts Competition of Industrial Designs, 1933, and is now to be produced at their Morley Works.

The designer was Mr. Leonard Yoke, of London.

The Electric Eye

In this way, the very compact and simple direct-reading "Tavolux" photometer now being supplied by Messrs. Stafford and Leslie (Armour House, St. Martin's-le-Grand, London) may well be described. This instrument, which is advertised elsewhere in this number, utilises a light-electric element connected with a moving coil recording device. The observer has merely to present the element to the light and the illumination is recorded by a moving pointer.

We understand that the firm is now considering the appointment of agents in Canada, New Zealand, the Malay States, and possibly other British Dominions not yet covered. We commend this matter to the notice of readers abroad who are interested in illumination and have the necessary qualifications to act as agents. We imagine that a live man would find this a very useful line to develop.

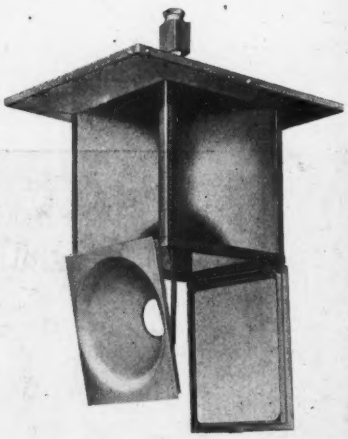
Conferences for Architects

Commencing January 17, 1934

As we go to press we learn that a **Conference** on Lighting for the benefit of Architects, similar to that run so successfully last year, will commence on **January 17.** We have received from the E.L.M.A. Lighting Service Bureau a copy of the attractive programme prepared. Those interested should apply at once to the Lighting Service Bureau at 2, Savoy Hill, London, W.C.2.

Lanterns for Escura Lamps

The accompanying view of the Ediswan "City" lantern, designed for use with the new "Escura" lamps and exhibited



THE EDISWAN "CITY" LANTERN

at the recent Transport Exhibition in London, illustrates how the tubular shape of the source has profoundly influenced the design of street lanterns —a new box-like but by no means unpleasing type being the result. This form of lantern would seem to lend itself well to assymetric effects; the distribution can be readily altered without the general appearance of the unit being much changed.

The Edgware Road, Hendon, a fine example of modern gas lighting. Formerly lighted by gas and electricity; now by gas only

OF NINETEEN COMPETITIVE STREET LIGHTING CONTRACTS RECENTLY AWARDED TO GAS UNDERTAKINGS IN VARIOUS PARTS OF THE COUNTRY TEN WERE ACTUAL **CONVERSIONS** TO GAS ● EACH CONTRACT WAS AWARDED FOR A PERIOD RANGING *from* 3 *to* 15 YEARS

for Efficient Street Lighting

THANK GOODNESS FOR

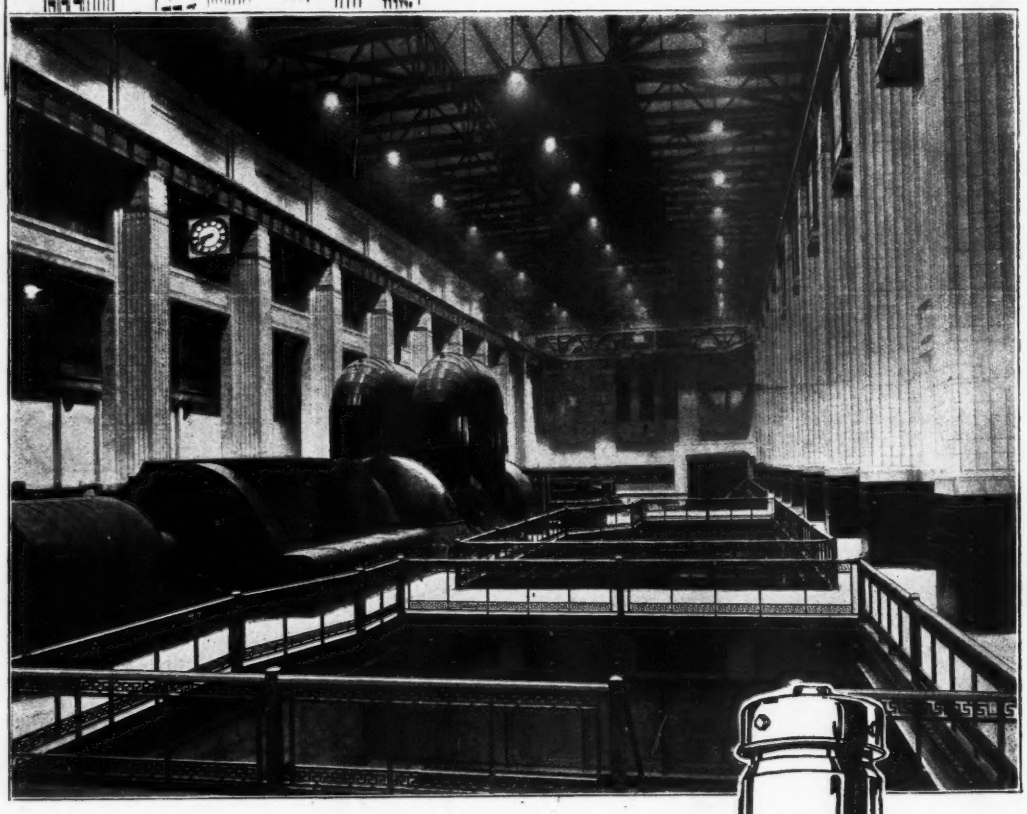
GAS

THE BRITISH COMMERCIAL GAS ASSOC. 28 GROSVENOR GARDENS, LONDON, S.W.1

BATTERSEA

The New Power Station for The London Power Company

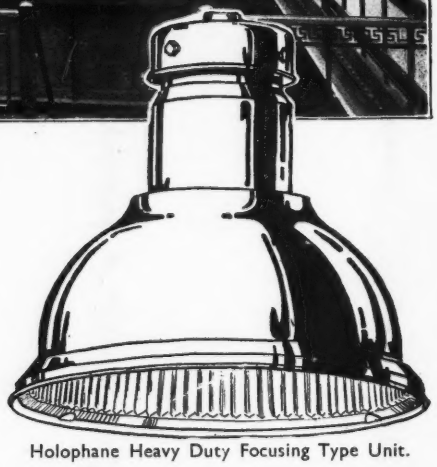
EQUIPPED



A night photograph of the Turbine House lighted by 1,000 watt Holophane heavy duty units

with

HOLOPHANE Lighting



Holophane Heavy Duty Focusing Type Unit.

The lighting of the Battersea Power Station has been carried out to a carefully planned scheme drawn up by the Engineers of Messrs. The London Power Company.
Holophane lighting has been specified and installed for all major positions in this power station undertaking.
The Electrical Contractors for this outstanding installation were Messrs. G. E. Taylor & Co., of 7, Suffolk Lane, Cannon Street, London.

Technical Booklet written by an expert, giving practical advice, and profusely illustrated, will gladly be sent free. We welcome the opportunity of giving specifications and specialized advice gratis.

HOLOPHANE, LTD.

1, ELVERTON STREET, VINCENT SQUARE, LONDON, S.W.1

Telegrams: "Holophane, Sowest, London." Telephone: VICtoria 8062 (3 lines)

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